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# ANNALS

OF

# The Entomological Society of America

JUNE, 1945

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PUBLISHED QUARTERLY BY THE SOCIETY
COLUMBUS, OHIO

Entered as second-class matter April 11, 1908, at the Post Office at Columbus, Ohio, under the act of Congress of March 3, 1879. Subject to rate of postage provided for in Paragraph 4, Section 538, P. L. & R., authorized September 16, 1940.

# The Entomological Society of America

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ANNALS
OF
The Entomological Society of America

Volume XXXVIII JUNE, 1945 No. 2

## THE ENTOMOLOGICAL SOCIETY OF AMERICA

### NEWS OF THE MOMENT

DEAR MEMBERS:

With this issue we are starting a new feature for the Society and publishing reports and business of the Society while the matters are still of interest. Previously all these matters have been published in one large report following the end of the year. We feel, however, that the members will appreciate being kept informed of progress of the affairs of the Society at timely intervals. We hope that you find these reports of interest.

Yours sincerely,

THE EXECUTIVE COMMITTEE.

### NEW MEMBERS

The following new members were recommended and nominated for membership in the Society since the annual meeting. They were elected to membership by mail ballot of the Executive Committee.

DOUTT, RICHARD, 616 Riverview Drive, Melbourne, Florida.
DUCHANOIS, LT. (j.g.) FRANCIS R., 721 Park Avenue, Corpus Christi, Texas.
FURMAN, CAPT. DEANE P., 197 Amherst Avenue, Berkeley, California.
GERBERICH, JOHN B., Dept. Zoology and Entomology, Ohio State University, Columbus, Ohio.
HAGEN, ELLSWORTH, 2647-22 Avenue, Oakland 6, California.
JONES, DR. SARAH ELIZABETH, Dept. of Biology, Texas State College for Women, Denton, Texas.
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KRAUSS, NOEL LOUIS HILMER, Plant Quarantine Inspector, Territory of Hawaii, 2437 Parker Place, Honolulu 5, Hawaii.
LAFFOON, JEAN, 1401 W. Third, Sioux City 17, Iowa.
REICHART, CHARLES V., Dept. Zoology and Entomology, Ohio State University, Columbus 10, Ohio.
ROBINSON, PAUL FRANCIS, 21 Fenwood Road, Boston 15, Massachusetts.
SNOW, WILLIS E., Dept. Entomology, University of Illinois, Urbana, Illinois.
WECHSLER, DR. HARRY I., 2125 Holland Avenue, Bronx, New York City, New York.
WEISGERBER, ADOLPH F., 340 N. 7th Street, Newark 7, New Jersey.
WILSON, KENT HALE, 430 Ridgewood Road, Fort Worth 7, Texas.
WORCESTER, DOUGLAS JOHN, P. O. Box 805, Puunene, Maui, Hawaiian Islands.

## REPORT OF THE REPRESENTATIVE TO THE DIVISION OF BIOLOGY AND AGRICULTURE, NATIONAL RESEARCH COUNCIL

The annual meeting was held at the National Academy of Sciences, Washington, D. C., April 14, 1945. Because of the closing of all business in the city of Washington, D. C., due to the death of President Roosevelt, a vote was taken to decide whether or not the meeting should be held or adjourned. Upon a unanimous vote, it was decided that the meeting should continue as planned.

*Roll Call:* The roll call showed that all of the members were present except three or four who were unavoidably detained because of other commitments. Entomology was represented by DR. JAMES I. HAMBLETON, representative of the American Association of Economic Entomologists, and myself.

*Agenda:* Minutes of the annual meeting of the Division of Biology and Agriculture were presented in mimeographed form. Reports of certain committees were reviewed without any action being taken.

*Bi-monthly Report of the Division of Biology and Agriculture:* This report indicated as Volume 3, No. 4, April, 1945. Among the topics for discussion were (1) functions of the members of the Division; (2) possibilities for rehabilitating research and instructional staffs; (3) the Army plan for postwar education; (4) the need for effective opportunities to permit biologists and agriculturists to serve in the national effort; (5) symptoms of enlarging opportunity for public service by biologists and agriculturists.

Under this last heading there was a topic entitled "Insect Control" in which the great interest in the use of DDT was presented. In order to study this material in connection with the needs of war, agriculture, fish and wild life, public health, and other phases, a coordinating committee in the broad field of insect control was named by DR. FRANK B. JEWETT, president of the National Academy of Sciences and ex-officio presiding officer of the Executive Board of this Division of the National Research Council.

The interesting thing about this committee is that not an entomologist was named thereon. M. C. WINTERNITZ, Pathologist and Director of the New Haven Hospital, was chairman. Other members of the committee consisted of W. MANSFIELD CLARK, Chemist, ROGER ADAMS, Chemist, ROBERT F. GRIGGS, Botanist, E. H. KRAUS, Botanist, L. H. WEED, Anatomist, and ROBERT LOEB, Pathologist.

In connection with this committee there was appointed a group of nine liaison members from government agencies. Among these were DR. ANNAND and DR. F. C. BISHOPP of the B.E.P.Q. So far as the reports indicated this committee has done nothing.

Personally, I wish to express myself most emphatically as opposing the practice of a highly intelligent scientist like DR. JEWETT appointing a committee on Insect Control without including in its membership a single entomologist. If it was possible to do so, I feel sure MR. HAMBLETON agrees with me that our entomological societies should file a professional protest with DR. JEWETT concerning this action. The entomologists of America are a well organized and fully recognized scientific unit, and have shown, especially in the research work being done with DDT that they are by far the most capable judges of the use of this material in the control of insects affecting agriculture, human health, and the armed forces of the country.

I expressed these feelings before the members of the Division and all agreed that the appointment of this committee was a grave error.

Additional topics discussed included (6) postwar security; (7) educational requirements for technical positions in the Civil Service; (8) fellowships; (9) reports of committees of the Division; (10) publications, finances, and personnel of the Division; (11) progress of the campaign for the compulsory enrichment of bread; (12) the effect of vitamin supplements on war workers.

The final matters presented to the members of the Division consisted of four recommendations of the Executive Committee which were as follows: 1, that the name of the Division shall be DIVISION OF LIFE SCIENCES; 2, that one

person ordinarily may not be chairman of more than one committee; 3, that a new committee be formed under the name "Committee on Publication in the Life Sciences;" and 4, that one or two boards be set up comparable to the two boards already established (Agricultural Board, Food and Nutrition Board) to cover the various fields of life sciences, such as microbiology and forestry. All of these recommendations were adopted by the Division. From now on it is to be expected that the title of the Division will be DIVISION OF LIFE SCIENCES.

A considerable amount of discussion was centered around the War Manpower Commission and the Roster of Scientific Men. Also the universal training bill was fully presented. A review of the demand for scientists was presented under four headings as follows:

I—*By Industry:* To be greatly increased. It is estimated that small companies are making plans to increase their scientific staffs by 300 per cent; medium size companies by 100 per cent; large companies by 100 per cent or slightly less.

II—*Employment:* To greatly increase the number of scientists through the United States Board of National Security.

III—*Foreign Demand:* The foreign demand will be greatly increased for American scientists until these countries are able to increase their own scientific groups. It is estimated that many of these foreign countries will send students to the United States so as to provide for these increases as rapidly as possible. For instance, it was assumed that India alone would send 250 men for Ph.D. training in America. As an illustration, it was stated that at Massachusetts Institute of Technology, foreign students now outnumber American students.

IV—*Supply:* The supply for this increase is estimated to be about as follows: Engineering 18 per cent of the normal supply of trained men for 1940–41; Physical Chemistry about 18 per cent; Biology and Agriculture about 9 to 11 per cent of the 1939–40 supply; Liberal Arts about 20 per cent of normal.

It was also pointed out that at the present time, foreign countries are maintaining a much higher level in the training of scientists than in this country. This is especially true in Russia where a very great increase over normal is being maintained; in England where also an increase in the number of scientists is being produced; in Australia with an increase of 50 per cent over normal; and Canada, with a 25 per cent increase over normal. These figures indicate very clearly the laxity of our government in providing for the greatly needed scientists for the future development of this country.

*Remedy:* As a remedy for conditions in this country, it was stated that a bill is being prepared to provide for special training of outstanding graduates in various scientific fields. This is to include the recommendations for a Federal Fellowship Program.

It was estimated that there would be a 60 per cent increase in students attending institutions of higher learning in the United States three years after demobilization. In view of all of this information and following a rather lengthy discussion it was moved that the incoming executive committee of the Division of Biology and Agriculture select a committee whose duty it would be to provide the necessary information for institutions and organizations to meet the various exigencies that may occur. It was further suggested that members of the committee nominate some one member of their profession as a member of this committee. Action approved by vote.

Our suggestion was ROGER C. SMITH and I am writing the committee making such a recommendation. This of course is due to DR. ROGER C. SMITH'S important part in connection with the National Roster of Scientific Men at this time.

The report of the nominating committee included my name as a member of the executive committee for the coming year.

*Additional Boards for the Division:* In order that the various scientific subjects in the Division be fully represented, a number of additional boards were suggested. In order that the material might be fully and carefully studied, a motion was passed providing for a committee to study all of the various fields of the Division in order to set up one or more additional boards which might be needed to adequately cover the various fields of life sciences and to make specific recommendations to the Division. In the discussion a Board of Entomology was considered.

Respectfully submitted,

E. O. ESSIG, *Representative.*

## SOCIETY BUSINESS AND APPOINTMENTS

*Managing Editor.*—Early in April DR. C. H. KENNEDY resigned as Managing Editor of the Annals and appointed DR. ARTHUR GIBSON as Chairman pro tem of the Editorial Board to recommend a successor to the post of Managing Editor. DR. GIBSON canvassed the Editorial Board and transmitted their unanimous recommendation of PROFESSOR A. W. LINDSEY, Denison University, Granville, Ohio, to the Executive Committee. The Executive Committee confirmed DR. LINDSEY's appointment unanimously by mail ballot.

At the same time the Executive Committee voted to pay the traveling expenses of the Managing Editor to the annual meetings of the Society. It was felt imperative that the Editor attend the business meeting and Executive Committee meeting at the annual meetings of the Society in the interest of discussing business matters pertaining to the Annals.

*National Research Council*—Following receipt of DR. ESSIG's report, the Executive Committee voted to send a protest to the National Research Council on their failure to include entomologists in their Committee on "Insect Control." The Secretary forwarded this letter July 9.

HERBERT H. ROSS,
*Secretary-Treasurer.*

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## PERSONAL BIBLIOGRAPHIES

During his editorship DR. C. H. KENNEDY emphasized the importance of personal bibliographies. I should like to add my hearty endorsement. Entomological papers of enduring value may be widely scattered and many shorter articles are easily overlooked. Only the author can have absolute knowledge of his complete list of publications. If modesty forbids anyone to put his list into permanent form, let me assure him that it is a definite service to the entomological world.

The following bibliographies have accumulated on the editor's desk. They may presumably be obtained from the authors.

ALLARD, H. A., Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture, Division of Tobacco Investigations. 185 titles, chiefly on plants, birds, amphibians, reptiles and insects; 13 typewritten pages, photostat.

FERRIS, G. F., Stanford University, Palo Alto, California. 33 titles for the period 1937 to 1944 inclusive. Chiefly on scale insects (Homoptera: Coccoidea). A few on Hemiptera, Neuroptera, Diptera and topics of general entomological interest. Printed, 2 pages.

CHAMBERLIN, RALPH V. Compiled by DAVID T. JONES, Vinton, Iowa. 290 titles on a wide range of subjects. The taxonomic papers deal chiefly with Myriapoda and Arachnida. Several concern mosquito control. Vintonia, Vol. IV, 22 pages, lithoprint, 1944.

WEBER, NEAL A., University Station, Grand Forks, North Dakota. 37 titles, chiefly on ants, 1934–44, 2 pages, mimeographed.

# THE RELATION OF SPRING MOVEMENTS OF THE BEET LEAFHOPPER (EUTETTIX TENELLUS BAKER) IN CENTRAL CALIFORNIA TO TEMPERATURE ACCUMULATIONS (HOMOPTERA)

WILLIAM C. COOK[1]

United States Department of Agriculture,
Agricultural Research Administration,
Bureau of Entomology and Plant Quarantine

During April and May the spring brood of the beet leafhopper disperses from the semidesert plains and foothills bordering the western and southwestern portions of the San Joaquin Valley of California into the cultivated districts of the Great Valley. The destructive curly top disease which it carries causes considerable damage to sugar beets, garden beets, tomatoes, and melons in this area, as well as to various ornamental plants. The growing of varieties of sugar beets resistant to the disease has greatly reduced the damage to that crop, but resistant varieties of the other crops mentioned are not available. Direct control of the leafhopper after it reaches these crops has not proved feasible, so indirect methods must be sought. One method of reducing or avoiding damage is by so timing the planting or setting of these crops in the field that they are not present at the time of the spring migration of the leafhopper.

Because there is considerable variation from year to year in the time of the spring movements of the leafhopper, it is highly desirable to develop some method of estimating, at least a short while in advance, when the migrations will probably occur. It is not necessary to estimate the dates of migration with great accuracy, as a variation of a week or so in planting will make little difference in liability of infestation of tomatoes and beans in this area. The present study is rather crude, as can be seen later, and in this it reflects the lack of accuracy in the basic data.

Spring temperatures in the San Joaquin Valley become higher in the south than in the north and dispersals of the beet leafhopper from the southern areas usually precede those from more northern areas. This would indicate that the movements are related to a definite accumulation of temperature which may be necessary to mature the spring adults and prepare them for movement. This paper attempts to show that such a temperature accumulation exists and that it is of value in estimating the times of movement.

## METHODS

This study involves four basic assumptions, which may be outlined as follows:

1. Movements of the beet leafhopper are assumed to be closely related to the time of brood maturity.

[1]The writer is greatly indebted to Miss Margaret Abernethy, who performed most of the routine work in gathering and summing the weather data involved.

According to Severin (1933, p. 328), "The spring-dispersal flights of the beet leafhopper are probably associated with a food stimulus; the adults fly from the uncultivated plains and foothills after the pasture vegetation becomes dry and invade the cultivated areas when the annual saltbushes are succulent and most favorable from the standpoint of food and egg deposition."

This assumption of Severin is not always true. It has long been noticed in field work that collections of spring-brood adult leafhoppers taken on breeding hosts generally contain an excess of males. Since rearing experiments have shown the true sex ratio to be approximately 50 per cent females, these females must be leaving the hosts about as rapidly as they become adults.

Further evidence bearing on this point was obtained during the spring of 1939, when daily counts of leafhopper populations were made in two places near Coalinga, Calif., from April 15 to 26, which covered the period of maximum emergence of adults. The average numbers of males, females, and nymphs per square foot found in these counts have been plotted in figure 1. These data show a rapidly decreasing nymphal population, but a low, nearly constant adult population, which indicates that the adults move away nearly as fast as they mature. This movement was not due to drying of the food plants, because the adult population was about as high on April 26 as it was a week earlier, and there was sufficient green vegetation present during the interval to mature the nymphs found on the earlier date.

The irregularities in these data are due to two causes. The counting methods were not sufficiently accurate to give precise numbers of the tiny first instars, and no effort was made to obtain consecutive counts on the same identical areas, so local variations in population density are reflected. Aside from these irregularities, the data support the assumption that the adults leave the breeding areas as rapidly as they mature, regardless of the condition of the vegetation. They do not always move any great distance but may disperse over nearby areas until favorable conditions develop for a general movement into previously unoccupied or lightly occupied territory.

2. There is assumed to be a linear relationship between temperature and the rate of development of the leafhopper eggs and nymphs. This is not strictly true for all temperature values, and this particular point has been studied by many workers. Uvarov (1931, pp. 19–38) recently gave an excellent review of the status of the problem. Glenn (1922) used a temperature sum above the threshold of development for predicting the time of emergence of various broods of the codling moth in Illinois, but he corrected his sums for temperature above the optimum by subtracting twice the sum above the optimum from the sum below that point. Bodenheimer (1925) successfully used the temperature sum above the threshold of development for predicting the time of appearance of the various broods of *Ceratitis capitata* (Wied.). Shelford (1927) used a method of summing "developmental units," which were not strictly proportional to temperature, but were corrected for humidity as well as for the departures from linearity of the temperature curve. There is no question regarding the superior accuracy of such a method

as that of Shelford, but for a study such as the present one such refinements are not necessary. Harries and Douglass[2] have shown that the relation of temperature to the growth of the beet leafhopper is approximately linear between 60° and 92° F., but curvilinear above and below these points. The departure from linearity at the low-temperature end of the line is not large, and temperatures above 92° rarely occur during

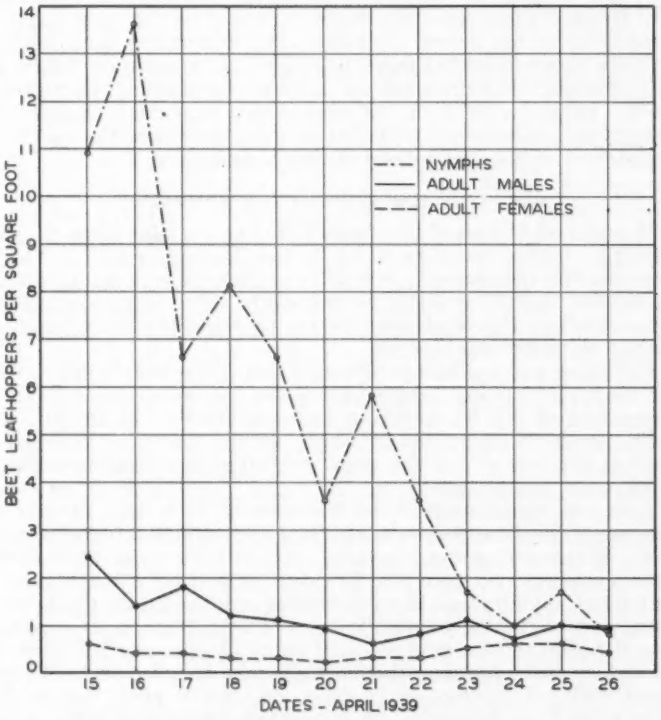


Fig. 1. Beet leafhoppers per square foot found in breeding areas near Coalinga, Calif., April 15 to 26, 1939.

the period under consideration, so it is safe to assume a linear relationship as a first approximation. Even if the relation is not strictly linear, the departures would tend to cancel out in a study involving a 3- or 4-month period.

3. Shade temperature, as taken in a standard Weather Bureau shelter, is assumed to be an index of the temperature under a sparse cover of vegetation on warm slopes in the sun. This assumption is

[2]Harries, F. H., and Douglass, J. R. Bionomics of the beet leafhopper under natural and controlled conditions. (Not yet published.)

open to question, and its validity can be judged only by the results obtained. For short periods when cloudy or rainy days may be more frequent than usual, the relation would not be valid; but for comparing the sum total of temperature for 3 or 4 months in different years, disturbing factors should counterbalance one another to some extent, and the relationship should hold in a general way.

4. The average of readings of maximum and minimum thermometers is assumed to give the mean temperature for each day. As Hartzell (1919) has shown, the mean of maximum and minimum temperatures varies somewhat from the true mean temperature determined by planimeter measurements of a carefully checked thermograph record. In this case such variation is not important, because the readings are not assumed to be the temperature where the insects are located, but are used as indexes of that temperature.

### BASE LINE FOR TEMPERATURE SUMMATION

Harries and Douglass[2] have shown that in the laboratory the theoretical threshold of development for the beet leafhopper is 57.5° F. This represents the temperature to which the insect was actually exposed. The weather records available for this study, taken under shade conditions in Weather Bureau shelters, did not represent the actual conditions to which the insect was exposed.

Field observations during the winter and spring months have shown that the overwintering female leafhoppers are very active at an air temperature of 50° F., and completely inactive at about 40°. The lowest (shade) temperature at which activity has been consistently observed is about 45°, so this point was taken as a base for summing the recorded temperatures.

After the original analysis had been completed in 1935, further confirmation of this base point was obtained from field observations. During the winter and spring months of 1935 to 1938, a soil thermograph was maintained in a favorable breeding ground on a south slope in Los Banos Canyon, about 12 miles southwest of Los Banos, Calif., in the central part of the San Joaquin Valley. The bulb of the thermograph, covered with a thin layer of soil held on by shellac, was half buried in the surface soil. Another thermograph was installed in a Weather Bureau shelter at the foot of the slope, less than 25 yards distant. The charts were of the cylindrical type, on which the temperature could be read within 1 Fahrenheit degree and the time within 15 or 20 minutes. When these charts were being read, 58° F. was taken as the threshold instead of 57.5°, as the charts were marked with lines at 2-degree intervals.

The chart of the soil thermograph was first examined, and a record was made of the time each day when the temperature crossed the 58° line, either rising or falling. The chart of the standard shade thermograph was then examined and record made of the shade temperature at those times. A few records were incomplete for various reasons, and there were periods when the temperature did not go above 58° F., but, in all, 163 instances of rising temperature and 159 cases of falling temperature were obtained. The shade temperatures corresponding to

a soil-surface temperature of 58° F. have been plotted as a frequency polygon in fig. 2.

The original data give a mean for rising temperatures of 46.04° F., and for falling temperatures of 47.85° F. The graph shows a definite mode at 45°. The exact determination of this value is not necessary in the present study.

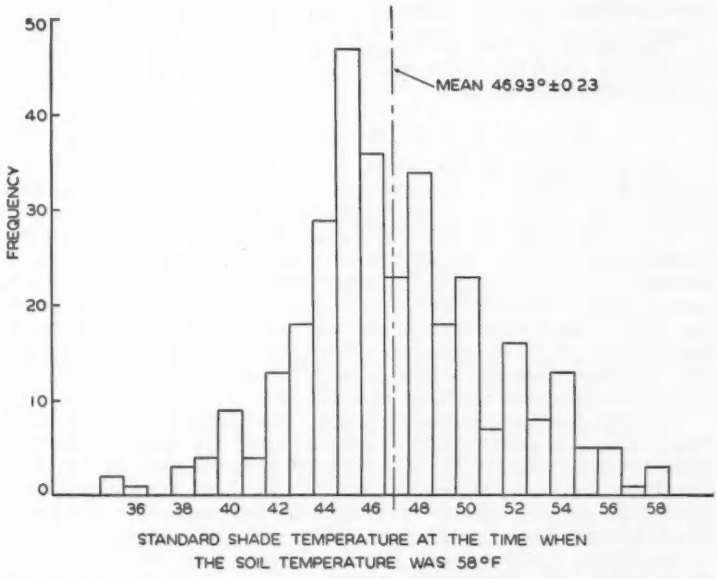


FIG. 2. Frequency polygon showing the distribution of shade-temperature values at the time when the soil-surface temperature was 58° F.

## TEMPERATURE RECORDS USED

Records for the following stations of the United States Weather Bureau were used for the periods indicated:

| | | | |
|---|---|---|---|
| Bakersfield | 1919–40 | Maricopa | 1919–40 |
| Coalinga | 1919–40 | Merced | 1921–40 |
| Dudley | 1919–38 | Middlewater | 1919–40 |
| Fresno | 1921–40 | Modesto | 1928–40 |
| Helm | 1929–40 | | |

The Standard Oil Company of California operates pipe lines which traverse the breeding areas of the beet leafhopper, and their employees keep weather records at many of their stations. They supplied the following records through the courtesy of their Pipe Line Department:

| | | | |
|---|---|---|---|
| Corcoran | 1919–35 | Mendota | 1919–36 |
| Kettleman City | 1932–40 | Patterson | 1919–35 |
| Lost Hills | 1919–31 | Taft (Midway) | 1919–40 |

In addition to these records, the Modesto laboratory of the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture has maintained four stations in the San Joaquin Valley equipped with standard maximum and minimum thermometers in Weather Bureau shelters. These furnished data for the following places and periods:

| | | | |
|---|---|---|---|
| Corcoran | 1930–40 | Mercey Hot Springs | 1930–40 |
| Los Banos Valley | 1933–40 | Panoche Junction | 1938–40 |

The station at Panoche Junction is operated by employees of the Pacific Gas and Electric Company. The locations of all these weather stations are shown in fig. 4.

### ADJUSTMENTS MADE IN SUMMING TEMPERATURES

Many of the available records are in the form of monthly mean temperatures. Daily temperatures are available only for the stations operated by the Modesto laboratory, for those of the Standard Oil Company since 1931, and for Bakersfield, Fresno, Merced, and Modesto of the United States Weather Bureau. In using monthly means a correction is necessary for those months in which the monthly mean temperature falls close to 45° F. If uncorrected figures are used, a recorded monthly mean temperature of 45° will add nothing to the apparent summation. Actually, however, a mean of 45° is obtained by averaging days warmer than this temperature with colder days, so that some effective temperature has been accumulated.

In order to evaluate this correction, about 100 records were assembled for various stations and months in which the mean temperature fell between 35° and 60° F. The daily mean figures were used to calculate the actual day-degrees above 45°, and these sums were plotted against the monthly means. It was found that the uncorrected figures could be used when the mean was above 52°, and that no significant accumulation occurred when the mean was below 39° F. Between these points the relation was curvilinear. A second-degree parabola was fitted to the data by least squares, and the corresponding values of mean monthly temperature and accumulation per day above 45° were tabulated. The original data and the computed curve are shown in fig. 3.

The curve was checked against other stations and months for which daily data were available, and the maximum error found was 10 day-degrees. The average error was somewhat under 5 day-degrees.

### DETERMINATION OF THE DATE FROM WHICH TO SUM TEMPERATURES

As stated above, the female beet leafhoppers of the fall brood live through the winter and lay their eggs early in the spring. Mature eggs are rarely found in the ovaries of the females before the middle of January. The rate of development of the ovaries seems to depend upon food as well as upon temperature, so it may also be influenced by length of time between the maturing of adults of the fall brood and the germination of succulent winter annuals. Thus the basal date for summing temperatures should lie somewhere between October 15, when the majority of the fall adults mature, and February 1, when they are actively laying their eggs.

A long preliminary study was undertaken, in which various dates such as the dates of fall movements, the dates of germination of winter annuals, and the dates of first oviposition were tried as bases. The criterion by which they were judged was the constancy of the temperature sum over a 20-year period. The basal date finally selected was January 1. For some time around this date there is very little accumulation of effective temperature, and this date lies close to the beginning of the oviposition period. Experimental and field studies of the vitality and fat reserves[3] have shown that the physiological

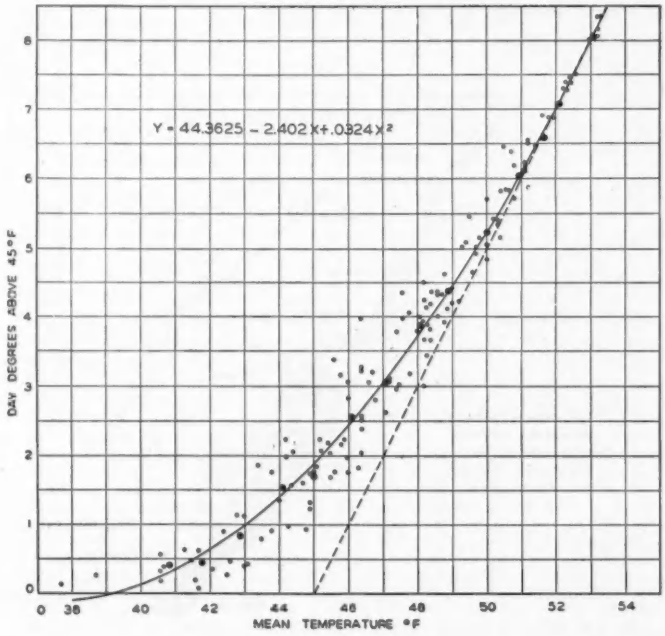


FIG. 3. Fitted curve showing the relation between monthly mean temperatures and day degrees above 45° F. The small circles represent individual observations, while the large black dots are average of observations within an interval of 1 Fahrenheit degree (e.g., 44.5° to 45.4° incl.)

condition of the overwintering females is about the same each year during January. Field data on oviposition and dissections of the female leafhoppers indicate that very few, if any, eggs are laid before January 1 in normal seasons. The assumption involved, therefore, in the use of this date is that the leafhoppers are in about the same physiological condition at this time each year, regardless of fall conditions.

[3]Cook, W. C. Studies of the vitality of the beet leafhopper during the winter in California as related to the fat content of the females. (Unpublished.)

DATES OF OBSERVED MIGRATIONS

Dates on which movements of beet leafhoppers have been observed have been recorded by Severin (1933). E. A. Schwing, entomologist of the Spreckels Sugar Company, very kindly furnished the Modesto laboratory with a much more inclusive set of data from his observations over the period 1919–32. Since 1930 the staff of the laboratory has observed many movements, and the data from 1930 to 1940 are largely from records of the Bureau of Entomology and Plant Quarantine. When records are available from more than one source, these have been checked against one another, and the most probable date chosen, which is usually an average of the recorded dates.

FIG. 4. Map of the San Joaquin Valley showing the geographic areas where important beet leafhopper breeding occurs, and the stations whose weather data were used in these studies.

Spring movements of the beet leafhopper consist of short local drifts around and out of the breeding grounds, not extending more than a few miles, and long-distance movements which may cover 100 miles or more in this part of California. The movements recorded may have been of either type, and in many instances it is impossible to decide which type was noted. As a further complication, often the migrations were checked by survey trips over the areas subject to migration, and when new infestations were found, movements were recorded as having occurred between the two dates when surveys were made. Because of these

various complicating factors, definite single dates are given only when it is definitely known that a movement occurred on that date, and pairs of dates indicate that the movement occurred sometime in the included interval.

There is no certainty that the first movement recorded in the earlier years was actually the first movement to occur. Although the early field work was of such a nature that no important movement could have escaped notice, yet light movements from areas containing very few leafhoppers might have been undetected. Since 1930 the first movements have been watched for very closely. The known dates of movement from the winter breeding areas into the San Joaquin Valley for the period 1919–35 have been compiled in Table I.

TABLE I

DATES OF OBSERVED SPRING MOVEMENTS OF THE BEET LEAFHOPPER IN THE SAN JOAQUIN VALLEY OF CALIFORNIA

| YEAR | DATES OF OBSERVED MOVEMENTS | | | |
|---|---|---|---|---|
| 1919 | April 8 | April 14 | April 28 | |
| 1920 | April 23 | | | |
| 1921 | April 6 | April 14 | April 25 | May 7 |
| 1922 | May 17 | | | |
| 1923 | April 23 | | | |
| 1924 | April 6 | April 14 | April 22 | |
| 1925 | Mar. 29 | April 4–8 | April 13–17 | |
| 1926 | April 19–20 | | | |
| 1927 | April 21–26 | | | |
| 1928 | April 8 | April 14 | April 22 | |
| 1929 | April 9 | April 15–17 | April 30 | |
| 1930 | April 13 | April 17 | April 30 | |
| 1931 | April 7–9 | April 15 | | |
| 1932 | April 10 | April 12–14 | April 19–20 | April 29 |
| 1933 | April 13 | April 16 | April 22 | |
| 1934 | Mar. 25–27 | April 3 | April 7 | |
| 1935 | April 24 | April 28 | May 4 | |

The most striking feature of Table I is the variation in the times of movements in different years. The date of May 17, 1922, probably does not represent the earliest movement to occur in that season, but was the only movement to be detected; otherwise, the first recorded movements have occurred as early as March 25, and as late as April 24. Usually, though not shown in this period, from three to five movements have been observed. When three movements were recorded, they probably represented movements from the southern, central, and northern parts of the valley.

## EVALUATION OF THE TEMPERATURE SUM

Having determined that 45° F. was a suitable base from which to sum temperatures, and that January 1 was probably the best date for a starting point, the next step was to evaluate the temperature sum. For this purpose the migration dates were used from those years in

which three or more migrations were observed. The first date in each line in Table I is assumed to be that of the movement from the southern part of the valley, and the second date that of the movement from the central part of the valley. Temperature data from Taft, for the southern end of the breeding area, and from Coalinga for the central part of the area, were used to determine the temperature sums. The number of day-degrees above 45° from January 1 to the date of the movement at Taft and to the date of the movement at Coalinga in each year were calculated, and the resulting sums are given in Table II.

TABLE II

TEMPERATURE ACCUMULATIONS IN DAY-DEGREES ABOVE 45° F. AT TAFT AND COALINGA, CALIF., FOR THE PERIOD FROM JANUARY 1 TO THE DATES OF THE FIRST AND SECOND OBSERVED MOVEMENTS, RESPECTIVELY

| Year | Date of First Movement | Temperature Sum at Taft | Date of Second Movement | Temperature Sum at Coalinga |
|---|---|---|---|---|
| | | *Day Degrees* | | *Day Degrees* |
| 1919 | April 8 | 587.7 | April 14 | 630.7 |
| 1921 | April 6 | 876.1 | April 14 | 859.8 |
| 1924 | April 6 | 812.7 | April 14 | 954.1 |
| 1925 | Mar. 29 | 798.2 | April 6 | 868.0 |
| 1928 | April 8 | 921.5 | April 14 | 1,009.3 |
| 1929 | April 9 | 634.4 | April 16 | 611.1 |
| 1930 | April 13 | 1,107.4 | April 17 | 1,070.2 |
| 1932 | April 10 | 776.8 | April 13 | 796.2 |
| 1933 | April 13 | 812.9 | April 16 | 804.7 |
| 1934 | Mar. 26 | 698.2 | April 3 | 802.8 |
| 1935 | April 24 | 924.9 | April 28 | 754.6 |
| Averages | April 8 | 813.7 | April 14 | 832.9 |

Average Day-degrees at both stations, 823.3.

It will be noted that there was a wide range between the temperature sums in different years. This is to be expected because of the nature of the original data. Even though all years were omitted in which less than three movements were observed, there is still no certainty that the first and second observed movements originated in the southern and central areas, respectively. For example, the movements in 1919 and 1929 might have been either forced movements, caused by premature drying of the annual vegetation, or drifts of early-matured leafhoppers from the warmest parts of the area. On the other hand, the movements of 1930 might have come from more northern breeding areas. The variation was greatly reduced in the period following 1930, when the movements were under closer observation.

The average temperature sum at Taft is about 19 day-degrees lower than that at Coalinga, but the correspondence is really close. Near the time of the spring movements temperature is accumulating at a rate of 15 to 36 day-degrees per day, so a single day would account for this difference. Since the average of the temperature accumulations at these two stations was 823.3 day-degrees, 825 day-degrees was chosen in order

to have a round number for computation. Owing to the rapid accumulation of temperature near the end of the period, it would have made little difference if any point between 815 and 835 day-degrees had been used.

### CORRESPONDENCE BETWEEN CALCULATED TEMPERATURE ACCUMULATIONS AND OBSERVED MOVEMENTS OF THE BEET LEAFHOPPER

The thermal constant of 825 day-degrees above 45° F. between January 1 and the date of spring movement was calculated for the period 1919–35 during the winter of 1935–36, and the observed dates of movement during the period of 1936–40 may be used to test its accuracy. During this period the dates of observed movements were determined closely from intensive field work. In many cases the movement was not directly observed, but the approximate date was determined from the fact that populations of beet leafhoppers increased significantly in areas subject to migration between two dates when surveys were made. In other cases weather conditions were favorable for movements over a period of several days, and the whole period must be regarded as a date of migration. The dates of movements in the San Joaquin Valley during the period of 1936–40 were as follows:

| *Year* | *Dates of Observed Movements* |
|---|---|
| 1936 | April 9–12, April 17. |
| 1937 | April 20–25, May 2. |
| 1938 | April 20–25, May 3–7, May 7–12, May 12–17. |
| 1939 | April 4–5, April 15–19, April 21–27, April 27–May 5. |
| 1940 | April 1–2, April 5–8, April 15–19, April 27, May 1, May 10–14. |

During these years from two to six major movements were detected each season. In 1940 a second brood of leafhoppers was produced in the plains and foothills areas, and field work showed that the movements of May 1 and May 10–14 were made up almost entirely of second-brood leafhoppers. As it is not normal for second-brood movements to be of sufficient magnitude to be recorded, these two movements are omitted from the calculations which follow.

For the purpose of this analysis the portions of the San Joaquin Valley where extensive spring breeding of the beet leafhopper occurs may be divided into five geographic areas, which are shown, together with the locations of weather stations, in fig. 4. These areas differ in spring temperatures, and the leafhoppers normally mature first in the southern foothills, followed by those in the southern plains, central foothills, central plains, and northern foothills, in about the order named. In any season one or more of these areas may produce so few leafhoppers that no definite migration is detected, and at other times a single movement may include leafhoppers from more than one area. The movements observed during the period 1936–40 have been assigned to the areas from which they are known to have come, as shown in Table III. Directly beneath each observed date is the date that was calculated from temperature data, and the difference between the calculated and observed dates. In calculating these differences the midpoint of the period was used for the observed date when two inclusive dates are given. The difference is positive (+) when the observed migration

occurred after the calculated date, and negative (−) when the observed migration preceded the calculated date.

TABLE III

COMPARISONS OF ACTUAL DATES OF SPRING MIGRATIONS OF THE BEET LEAFHOPPER IN THE SAN JOAQUIN VALLEY WITH DATES CORRESPONDING TO THE SUMMATION OF 825 DAY-DEGREES ABOVE 45° F. AFTER JANUARY 1

| Year and Item | Southern | | Central | | Northern Foothills |
|---|---|---|---|---|---|
| | Foothills | Plains | Foothills | Plains | |
| *1936* | | | | | |
| Observed.... | ..... | ..... | 4/9–12 | 4/17 | 4/17 |
| Calculated... | 3/18 | 3/30 | 4/9 | 4/16 | 4/18 |
| Difference*.. | ..... | ..... | +1.5 | +1.0 | −1.0 |
| *1937* | | | | | |
| Observed.... | 4/20–25 | 4/25–5/2 | 5/2 | 5/2 | ..... |
| Calculated... | 4/18 | 4/22 | 4/28 | 5/6 | 5/15 |
| Difference*.. | +4.5 | +6.5 | +4.0 | −4.0 | ..... |
| *1938* | | | | | |
| Observed.... | 4/20–25 | 4/20–25 | 5/3–7 | 5/7–12 | 5/12–17 |
| Calculated... | 4/19 | 4/26 | 4/29 | 5/7 | 5/14 |
| Difference*.. | +3.5 | −3.5 | +6.0 | +2.5 | +0.5 |
| *1939* | | | | | |
| Observed.... | 4/4–5 | 4/15–19 | 4/15–19 | 4/21–27 | 4/27–5/5 |
| Calculated... | 4/11 | 4/13 | 4/16 | 4/24 | 4/26 |
| Difference*.. | −6.5 | +4.0 | +1.0 | 0.0 | +5.0 |
| *1940* | | | | | |
| Observed.... | 4/1–2 | 4/1–8 | 4/15–19 | 4/15–19 | 4/27 |
| Calculated... | 3/27 | 4/1 | 4/9 | 4/12 | 4/24 |
| Difference*.. | +5.5 | +3.5 | +8.0 | +5.0 | +3.0 |

*A minus sign (—) before the difference indicates that the observed migration occurred before the calculated date, and a plus sign (+) that the observed migration occurred after the calculated date. Differences given are between the calculated date and the midpoint of the observed migration period when this is more than one day.

No movement from the southern areas occurred in 1936, and no movement from the northern foothills was observed in 1937. The winter of 1935–36 was very dry in the southern part of the valley. There was no rainfall of importance until February, and the winter survival of leafhoppers was so small that no perceptible spring movements occurred. In 1937 the opposite condition occurred in the northern foothills. Rainfall was so heavy and the growth of winter annuals so rank that few suitable host plants were present.

The differences given in Table III are positive in 17 out of the 22 instances, zero in 1 instance, and negative in 4 instances. A positive departure is to be expected in many cases because the migration from any area is likely to be delayed after the date of maturity of the leafhoppers by unfavorable weather conditions. Obviously, favorable conditions that occurred before the development of the majority of leafhoppers could be followed by only a very light movement. The

average deviation between observed and calculated dates of movement was $3.64 \pm 0.46$ days, showing a very satisfactory agreement between the two during this period.

## SIGNIFICANCE OF THE TEMPERATURE SUM

Although the temperature sum of 825 day-degrees above 45° F. between January 1 and the date of spring movement was empirically derived, it seems to possess validity for this area, and indicates that after this number of day-degrees have accumulated migration is probable whenever weather conditions are favorable and sufficient adults mature. It is very doubtful whether this particular relation would hold in other parts of the range of the beet leafhopper, for several reasons.

In the first place, the base point used, 45° F., has been shown to be approximately the shade temperature when the soil temperature on south slopes passes 58°, the threshold of development for the insect. This relationship is fully valid only when the insect breeds on sunny southern or southwestern slopes. As it was first determined empirically from general field observations, it may be regarded as a sort of general average for this area, where much of the important spring breeding takes place on southern slopes. In other areas, where the most important breeding is on flats or gentle slopes, the base point might differ considerably. Furthermore, this relation would be altered by latitude, which would also vary the angle of incidence of the sun's rays; and by average cloudiness, which would affect the amount of sunshine.

Further, the magnitude of the temperature sum might well depend on slope, exposure, and latitude, as all these factors affect the amount of heat received per unit area. Another factor affecting the magnitude of the temperature sum is the host plants on which the nymphs are reared. Unpublished experiments have shown that the nymphs grow more rapidly on some hosts than on others, and the rate of growth on the dominant host plant would largely determine the time at which migration would normally occur.

However, although the base point for summing temperatures and the magnitude of the temperature sum might vary considerably in different places, this study indicates that migration is closely correlated with the accumulation of a definite amount of heat, and similar summations might be calculated for other regions within the range of the beet leafhopper.

## SUMMARY

Shade temperatures, taken in standard Weather Bureau shelters, have been successfully used for the calculation of dates on which major spring movements of the beet leafhopper in the San Joaquin Valley, California, may be expected. A temperature accumulation of 825 day-degrees above 45° F. after January 1 falls close to the date of movement. This thermal constant was calculated in 1935, and migrations during the period of 1936–40 have occurred, on the average, within $3.64 \pm 0.46$ days of the calculated date.

This particular summation would probably not be valid in other parts of the range of the beet leafhopper, as it depends on the relation between shade and soil temperatures, which would vary with latitude

and altitude, and also with the amount of sunshine. The summation is very useful, however, in the California area.

These studies indicate that the beet leafhoppers leave the breeding grounds at the first opportunity after they become adults.

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A HISTORY OF SCIENCE AND ITS RELATIONS WITH PHILOSOPHY AND RELIGION, by Sir William Cecil Dampier. Third edition, xxiii+ 574 pages. 1943. Cambridge University Press and The Macmillan Company. Price, $2.95.

How can a brief review do justice to such an imposing volume? If it were divested of its keen insight into the significance and relations of scientific discoveries, Dampier's work would still be great in its amazing comprehension of the progress of science from the dawn of civilization to the present day. Its treatment of details is necessarily brief but by referring to the parts dealing with his own specialty one gains confidence in the writer's keen appreciation of the significance of advances in all branches of science and in his correlation of scientific matter with other aspects of human life. The attitudes of contemporary scientists to questions of philosophy and religion and social values are puzzling, possibly because they are so varied and often so violently contradictory. Surely no one should be more ready to admit the inadequacy of knowledge than a scientist, yet few would have the courage to state, as Dampier does in the final paragraph of his introduction, the following position:

"At such historical moments [the modern period] physical science seems supreme. But the clear insight into its meaning which is given by modern scientific philosophy shows that by its inherent nature and fundamental definitions it is but an abstraction, and that, with all its great and ever growing power, it can never represent the whole of existence. Science may transcend its own natural sphere and usefully criticize some other modes of contemporary thought and some of the dogmas in which theologians have expressed their beliefs. But to see life steadily and see it whole we need not only science, but ethics, art and philosophy; we need the apprehension of a sacred mystery, the sense of communion with a Divine Power, that constitute the ultimate basis of religion."

The modern scientist must specialize. Only by specialization can he hope to add to the store of human knowledge which is now so intricately detailed. But if his contributions are to be more than the product of narrow interest and special aptitude his work must be carried on with a broad appreciation of the work of others and of the fabric and purpose of all scientific effort. The twofold obligation is heavy, but surely no scientist has crossed the threshold of the inner sanctum until he has assumed it, and surely no aspiring scientist can find a better guide to that end than Sir William Dampier's scholarly work.—A. W. L.

# NOTES ON THE MORPHOLOGY OF MOSQUITO LARVAE

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While studying mosquito larvae the writer has observed a number of characters not easily discerned on mounted larvae. These are the gula, gular sutures, maxillary spines, and certain hairs on the thorax, abdomen and air tube which are often best observed in a lateral or ventral view of the body.

The gular sutures are practically entire in most genera, extending from the margin of the buccal cavity to the margin of the occipital foramen, in which they become obsolete (Plate I, figs E-I). Anteriorly and inwardly they anchor the mentum, while on the posterior part of the head a pair of apodemes arise from them (ga, figs. A and E). In *Mansonia* the sutures are not prolonged beyond the apodemes (fig. D); in *Megarhinus* and *Anopheles* they do not attain the apodemes (figs. B and A); in *Uranotaenia* they are entirely lacking (fig. C).

The gula may be long or short with parallel sides or otherwise, depending on the shape of the head and the course of the gular sutures (cf. figs. F, H, and I). Laterally it is defined by the gular sutures, or, when the sutures are lacking as in *Uranotaenia* (fig. C), by the position of the gular apodemes. Anteriorly the gula may be angularly produced as in *Anopheles* and *Mansonia* (figs. A and D), evenly rounded as in *Megarhinus* (fig. B), produced into a spinous process as in *Culex* (fig. E), or truncate as in *Orthopodomyia* (fig. I). Posteriorly it is split from the occipital foramen (of, fig. D) for a varying distance along the mid-ventral line, except in the first three instars of *Anopheles* and the first instar of each of the other genera studied.

In the Chaoborinae the gula is present in *Corethrella*, but lacking in *Mochloynx*, in which case the buccal cavity is contiguous with the cervical membrane. The other genera are probably all similar to *Mochlonyx* with respect to the gula. The gular apodemes are absent in this subfamily.

Small, vestigial spiracles, first noticed in *Megarhinus* are present laterally on abdominal segments 1–7 (sp, fig. O), the mesothorax and usually the metathorax in all species of culicines examined. In *Anopheles* they are extremely small, if present, and their presence has not been detected in the Dixinae or Chaoborinae.

*Uranotaenia*.—This genus is strikingly different from other genera in both the larval and adult stages. Larvae of the two species occurring in the southeastern states, *U. sapphirina* and *U. lowii*, possess two salient distinguishing features (the elongate head and spinous head hairs) which are common in the genus but not present in all species.

[1]Contribution of the Georgia Department of Public Health.

The African *U. pallidocephalis*, for example, has the head much wider than long, and larvae of the species of the subgenus *Pseudoficalbia* usually have normal head hairs. Other characters common to the genus are the lateral plate of the eighth abdominal segment and the pecten teeth fringed on both margins, but here again several species do not conform to the rule and the lateral plate is a character of the fourth instar only. In two respects the two species studied differ from other North American genera and the first especially may possibly separate this from all other genera. These characters are the absence of gular sutures in all instars, already referred to, and the reduction of the lateral hairs of abdominal segments 3–6 in the later instars (fig. O).

Specific identification of mature *U. sapphirina* and *U. lowii* has heretofore been based on the upper lateral hair of abdominal segments 1–2[2], which is double in *lowii* and triple (though occasionally double or 4-branched) in *sapphirina*. Prothoracic hairs 3 and 13 offer characters to separate the two species in all the later instars. In *lowii* hair 3 is 5- to 7-branched and about a third shorter than hairs 1 and 2; in *sapphirina* hair 3 is 7- to 11-branched (4- to 8-branched in the second

[2]Since this was written an article has appeared in the Journal of Economic Entomology, Vol. 37, No. 4, pp. 543–4, by J. E. Pryor and R. W. Chamberlain, in which distinguishing characters of these two species are set forth. Prothoracic hair 3 is mentioned and figured, but hair 13 is not.

## EXPLANATION OF PLATE I

A–I—Ventral view of head of representatives of nine genera of mosquitoes, showing the nature of the gula and maxilla. The antennae, mentum, mouth brushes and usually the mandibles are not represented. The base of the mentum is usually represented by short dotted lines near the anterior end of the gular sutures. All heads are drawn to the same scale; A and C are fourth instar, B and H are second instar, and the remainder are third instars.

*A. Anopheles quadrimaculatus.* gs—Gular suture, ga—Gular apodeme.

*B. Megarhinus septentrionalis.*

*C. Uranotaenia sapphirina.* The origin of the gular apodeme in B and C is represented by a dot.

*D. Mansonia* (*Mansonia*) *titillans.* mx sp—Maxillary spine, sa s—Subantennal spine, a f—Antennal foramen, o f—Occipital foramen.

*E. Culex* (*Melanoconion*) *erraticus.* mx sp—Maxillary spine, g s—Gular suture, g a—Gular apodeme.

*F. Culiseta* (*Climacura*) *melanura.*

*G. Aedes mitchellae.*

*H. Psorophora* (*Psorophora*) *ciliata.*

*I. Orthopodomyia signifera.*

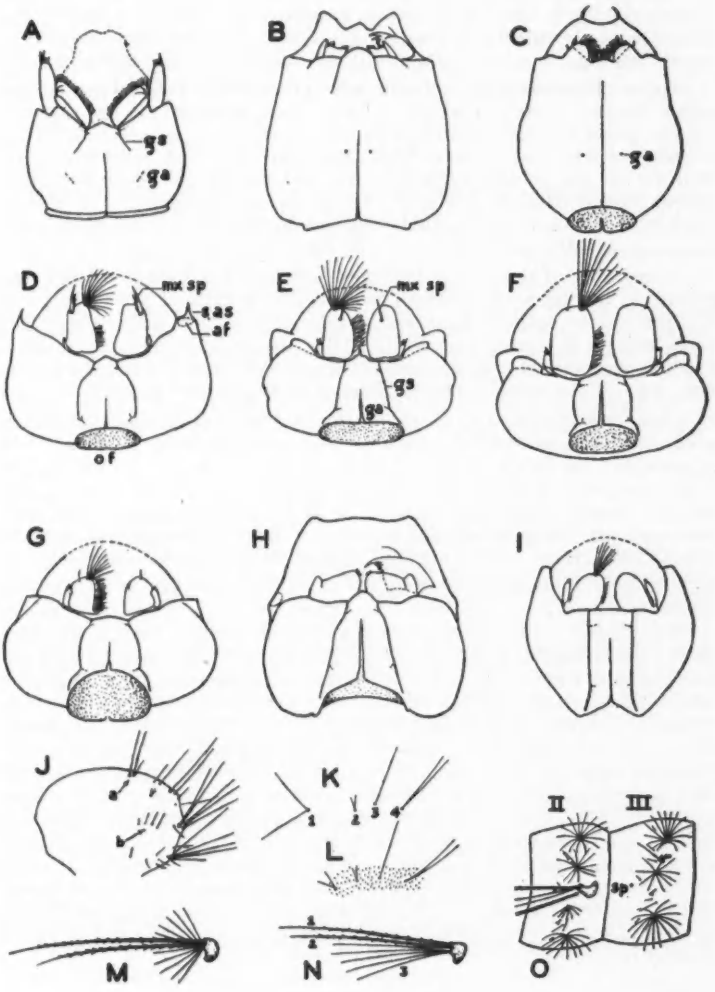
*J.* Thorax, dorsal view, showing (a) the dorsal submedian prothoracic hair group and (b) mesothoracic hairs 1–4. Prothoracic hair 13 is situated ventrally, below (a).

*K. Culex salinarius*, mesothoracic hairs 1–4.

*L. Culex nigripalpus*, mesothoracic hairs 1–4 and showing also some of the thoracic spicules.

*M. and N. Uranotaenia sapphirina* and *U. lowii.* Lateral view of the dorsal submedian prothoracic hair group (prothoracic hairs 1–3) and the platelet from which they arise.

*O. Uranotaenia sapphirina.* Lateral view of abdominal segments 2 (II) and 3 (III), showing the strong lateral hairs on segment 2. The corresponding hairs on segment 3, in the opinion of the writer, are indicated by an arrow. sp—Vestigial spiracle.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instar) and less than half as long as hairs 1 and 2. Or it may be said that hair 3 is larger and coarser than the stellate hairs on the thorax and abdomen in *lowii* and equal to the stellate hairs in *sapphirina*. Prothoracic hair 13, situated under the thorax near the head, is single (rarely double in the fourth instar) in *lowii* and multiple in *sapphirina*. Because of its protected position on the body, hair 13 is seldom or never lacking, no matter how mutilated or denuded the specimen.

*Culex* (*Melanoconion*).—Two characters separate this subgenus from other North American *Culex* in all instars. These are (1) the presence of two pairs of small lateral hairs on the air tube, in addition to the usual ventro-lateral hairs and (2) the maxillary spine is situated subapically on the ventral surface of the maxilla, instead of on the outer apical margin (fig. E, mx sp). The spine is also larger and heavier than in the other *Culex* studied. Species studied: *Culex* (*Melanoconion*) *erraticus*, *C.* (*M.*) *peccator* and *C.* (*M.*) *pilosus*.

*Mansonia* (*Mansonia*).—The maxillary spine is serrate in this subgenus, as has been previously noted.[3] This is true in all instars. In the first instar both margins are serrate; in the later instars only the inner margin is serrate (mx sp, fig. D). In the later instars the head capsule is produced into a spinous process below each antennal foramen (sas, fig. D). Species studied: *Mansonia* (*Mansonia*) *titillans*.

*Culex nigripalpus* and *C. salinarius* can be distinguished from each other in all the later instars by the nature of mesothoracic hair 1. In *nigripalpus* this hair is sub-equal in size to hair 2, and hairs 1, 2, 3 and 4 are sub-equally spaced (fig. L). In *salinarius* hair 1 is much larger than and more remote from hair 2 (fig. K). In the reduction of mesothoracic hair 1 *nigripalpus* differs not only from *salinarius* but from all other *Culex* known to the author. In *salinarius* hair 1 is single in the second instar and single to 4-branched (usually double) in the fourth instar.

The dorsal submedian prothoracic hair group ("inner shoulder hairs" of Edwards, 1932) comprises prothoracic hairs 1–3. In *Culex*, *Culiseta* and *Uranotaenia* they arise from a sclerotized platelet in the latter instars, with hairs 1 and 2 long, strong and single. Hair 3 is variable, and sometimes provides good specific distinctions, as previously described in *Uranotaenia*. Hairs 1 and 2 are usually as long or longer than the head in all instars The platelet is sometimes ill-defined or divided in the first instar. *Deinocerites* belongs to this group. Hairs 1–3 are quite similar to the above in *Mansonia* but the platelet is lacking. In *Wyeomyia*, *Aedes*, *Psorophora* and *Orthopodomyia* the platelet is lacking, and none of the hairs are long, strong and single (at least in the fauna of the Southeastern States), though one hair is very long and fine in *Orthopodomyia*. That the aforementioned is not applicable to all *Aedes* is shown by the Indian *Aedes* (*Finlaya*) *elsiae*, in which the platelet is present.[4]

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[3]King, Bradley, and McNeel, 1939, "The Mosquitoes of the Southeastern States," U. S. D. A. Misc. Publ. No. 336, p. 77.

[4]**Barraud, 1938.** Fauna of British India, Diptera, Vol. V, p. 182, fig. 39c.

SUMMARY

Several larval characters of mosquitoes not usually referred to are set forth, principally the gular sutures and the dorsal submedian prothoracic hair group. Distinctive characters of *Mansonia* (*Mansonia*), *Culex*, (*Melanoconion*) and *Uranotaenia* are discussed. New characters for separation of *Uranotaenia lowii* from *U. sapphirina* and *Culex nigripalpus* from *C. salinarius* in the later instars are proposed. The presence of vestigial spiracles on the sides of the thorax and abdomen is noted.

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SPIDERS OF THE GEORGIA REGION OF NORTH AMERICA, by RALPH V. CHAMBERLIN and WILTON IVIE. December 10, 1944. Bull. of the University of Utah, 35(9): 1–267, 217 figs. on 14 pls., four of which are colored. (Also listed as University of Utah, Biol. Ser. 8(5): 1–267, etc.) Published by the University of Utah, Salt Lake City.

"This paper was developed from a study undertaken initially to determine, as far as possible from available evidence, the proper application of the names based by Walckenaer upon Abbot's drawings of the spiders of Georgia. The validity of these names has not been seriously questioned since the recovery of the Abbot drawings in the Kensington Museum of Natural History at London in 1887 and the discussion among zoologists that ensued immediately thereafter."

"We have had available a set of photographs in black and white as well as kodachrome color slides made by the senior author on the occasion of a visit to the South Kensington Museum, London, where the originals have long been preserved."

"The material from the Georgia region is exclusively that of the University of Utah Collection. Some of our specimens were collected by the junior author on brief stops and on a more extensive trip in April, 1943. At this time thirty days were spent in the vicinity of Sylvania and Savannah with a brief excursion into the more mountainous territory between Gainesville and Clayton. Sylvania in Screven Co. is near the place where Abbot lived and did most of his collecting. * * * On this last expedition 350 recognizable species were taken. Some specimens taken in the autumn of 1943 have been received from Dr. D. Elden Beck, who collected at Fort Benning near Columbus. * * * The present list contains the considerable number of 552 species, of which number, however, 55 are at present of uncertain status, being mostly species described by Walckenaer. Sixty-nine forms are described as new."

Pages 7–24 of the Introduction are given to a critical discussion of Abbot's life and works and a list of 580 spiders collected by Abbot, many of which were named by Walckenaer. An excellent portrait of John Abbot is included. Abbot's date of birth and of death are not known, nor the place of birth. "He is known to have established himself in Georgia as a collector about 1776, apparently about 20 years old. Thereafter for something like 65 years he lived as schoolmaster, soldier in the Revolutionary war, for long as a prosperous planter and throughout as a keen observer, naturalist and gifted artist. During life Abbot maintained his connections with naturalists in Europe where he became widely known through the collection of insects, birds and plants. His paintings of birds and Lepidoptera were particularly famous." He sold chiefly through the agency of John Francillon, a silversmith on the Strand in London. Abbot's famous drawings are to be found in long series in the British Museum, 548 in the Boston Society of Natural History, 122 bird plates in the De Renne Library near Savannah, and in Europe at Paris, Zurich and Oxford.

This fine volume, beautifully illustrated, thus is a study of Abbot's work and is of as much interest in its notes on Abbot as in its careful study of spiders. It is at the usual high level of Chamberlin and Ivie spider papers.—C. H. K.

# A KEY TO THE NEW WORLD GENERA OF LIBELLULIDAE[1]

## (Odonata)

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One of the problems encountered by the student of New World Libellulidae is the lack of adequate keys to genera. While there are fairly good keys available for the North American genera, a great deal of the material from South America can be identified to genus only by comparison with determined specimens or after extensive checking of descriptions. The following key has been prepared in the hope that it may facilitate generic determinations, particularly of material from South America.

The writer is indebted to Dr. Clarence H. Kennedy of Ohio State University for the loan of material for study, the use of his extensive library, and for many helpful suggestions during the course of this study; to Dr. F. M. Carpenter of the Museum of Comparative Zoology at Harvard College for assistance in problems of wing terminology; to Prof. J. N. Knull of Ohio State University for the loan of material for study; to Dr. Frederick M. Gaige of the Museum of Zoology at Ann Arbor, Michigan, for the loan of material for study; and to many others who have seen and offered criticisms on this key.

### THE DEVELOPMENT OF KEYS TO THE LIBELLULIDAE

The first key to the known genera of Libellulidae is that of Brauer (1868). Brauer lists 40 genera, arranged in four groups, and gives a key to 39 of them (*Macrothemis* is not included in the key). For the genera involved, the key is a fairly good one. The principal characters used are those of the wings, the shape of the posterior lobe of the prothorax, and the shape of the abdomen. The latter character appears frequently, and the criteria in some of the couplets are rather vague. Twenty of Brauer's genera are represented in the New World; two of these (*Diplax* and *Mesothemis*) have subsequently been reduced to synonymy, and one (*Tramea*) has been renamed.

The second key to the known genera of Libellulidae is that of Kirby (1889), which includes 88 genera. This key uses most of the characters used by Brauer (except the shape of the posterior lobe of the prothorax), and a number of new ones; many of the characters used, especially those of the wing venation, are well defined and illustrated. The principal defect of this key is that it frequently uses such characters as relative size and shape, and as a result many criteria are not clear-cut.

[1]The term "Libellulidae" is used in this paper in its more restricted sense, and does not include the cordulines; it is synonymous with the term "Libellulinae" of many authors (Kirby, Ris, Needham, etc.). In our use of this term we follow the recent classification of the Odonata by Tillyard and Fraser (1938–1940).

Of the 88 genera listed by Kirby, 42 occur in the New World; five of these (*Coenotiata*, *Leptetrum*, *Mesothemis*, *Neocysta*, and *Potamothemis*) have subsequently been reduced to synonymy, three (*Belonia*, *Holotania*, and *Plathemis*) have been reduced to subgeneric rank, and two (*Ephidiata* and *Tramea*) have been renamed.

The next revision of the Libellulidae to contain a key, that of Karsch (1889), followed very closely upon Kirby's revision. Karsch lists 101 known genera which he arranges in the four groups proposed by Brauer, and includes keys to some of the genera. His keys are scattered through the paper and are intended only to sort out the main groups of genera and the individual genera in certain groups. For the most part, these keys are less workable than that of Kirby. Of the 101 genera, 47 occur in the New World; seven of these (*Aino*, *Coenotiata*, *Leptetrum*, *Malamarptis*, *Mesothemis*, *Neocysta*, and *Neothemis*) have subsequently been reduced to synonymy, three (*Belonia*, *Holotania*, and *Plathemis*) have been reduced to subgeneric rank, and two (*Ephidiata* and *Tramea*) have been renamed.

The next outstanding work on American Libellulidae to contain a key is that of Calvert (1901–1908). Although this work is concerned primarily with the Odonata of Central America, it covers fairly well the genera occurring from southern United States to northern South America. It keys out 29 genera; each genus keys out at a single point, and hence many of the items in the key are rather long. Though somewhat cumbersome, this key is more workable than the previous keys because the characters used are more clear-cut. Most of the characters used in previous keys appear in Calvert's key, and a number of new characters appear (e.g., femoral spination, the structure of the genitalia, and some additional venational characters). Of these 29 genera, one (*Plathemis*) has subsequently been reduced to subgeneric rank, and three (*Ephidiata*, *Platyplax*, and *Tramea*) have been renamed.

The most important revision of the world Libellulidae is the monumental work of Ris (1909–1919). This work serves as the starting point for most present taxonomic work in the group. Ris lists 120 genera, arranged in ten groups; he gives a key to the genera in each group but no key to the groups, and some of his groups do not appear to be very well defined. The group keys are rather cumbersome and difficult to use. However, the illustrations and descriptions given are excellent, and repeated reference has been made to them in the preparation of the key in this paper. Forty-four of Ris' 120 genera occur in the New World; two of them (*Sympetrum* and *Brachymesia*) have subsequently been divided, and two (*Ephidiata* and *Tramea*) have been renamed.

Since Ris' monographic work several regional papers have appeared which include keys to the Libellulidae (notably Garman, 1927, and Needham and Heywood, 1929) and two keys to the known genera have appeared (Needham and Broughton, 1927; Bartenef, 1929). Needham and Broughton present a revision of the group based on wing venation, grouping the 120 genera listed by Ris into eight tribes. Their key is based entirely on wing venation, and is inadequate for identification because it is based on only the type species in each genus. Bartenef

keys out 119 genera; he omits *Indothemis* Ris and *Misagria* Kirby (the latter a New World genus), and includes *Neothemis* Oguma (a Japanese genus not listed by Ris). His key uses a number of characters, including some not used in previous keys, but is rather unwieldy and fails to take into account many of the intrageneric variations.

One of the best keys to the neotropical genera of Libellulidae is that of the Williamsons. This key, which has unfortunately never been published, recognizes some new characters and takes into consideration more intrageneric variation than most previous keys. The Williamson key has been of considerable value in the preparation of the key in this paper.

The present key covers the 46 genera (with approximately 320 species and subspecies) which occur in North and South America and in the Antillean region. In preparing this key an attempt has been made to use characters that are easily seen and evaluated, and to take into account as much of the intrageneric variation as possible. Material of 41 of the 46 genera, representing over half of the species and subspecies involved, has been run through the key; in the case of genera and species not seen, the available descriptions have been carefully checked.

## THE NEW WORLD GENERA OF LIBELLULIDAE

Sixty-eight different generic names have appeared in the literature on New World Libellulidae. The valid names, which appear in the key, are listed below.

| *Genus* | *Reference* | *Genotype* | *No. of New World Forms*[2] |
|---|---|---|---|
| *Anatya* | Kirby, 1889, pp. 263, 293 | *guttata* (Erichson) | 3 |
| *Antidythemis* | Kirby, 1889, pp. 258, 267 | *trameiformis* Kirby | 1 |
| *Argyrothemis* | Ris, 1909, p. 26; 1911, p. 389 | *Argentea* Ris | 1 |
| *Brachymesia* | Kirby, 1889, pp. 262, 280 | *furcata* (Hagen) | 1 |
| *Brechmorrhoga* | Kirby, 1894, p. 264 | *grenadensis* Kirby | 15 |
| *Cannacria* | Kirby, 1889, p. 262, 300 | *herbida* (Gundlach) | 2 |
| *Cannaphila* | Kirby, 1889, pp. 259, 305 | *insularis* Kirby | 3 |
| *Celithemis* | Hagen, 1861, p. 147 | *eponina* (Drury) | 9 |
| *Dasythemis* | Karsch, 1889*a*, pp. 249, 251 | *venosa* (Burmeister) | 4 |
| *Diastatops* | Rambur, 1842, pp. 26, 135 | *pullata* (Burmeister) | 8 |
| *Dythemis* | Hagen, 1861, p. 162 | *rufinervis* (Burmeister) | 10 |
| *Edonis* | Needham, 1905, p. 113 | *helena* Needham | 1 |
| *Elga* | Ris, 1909, p. 27; 1911, p. 398 | *leptostyla* Ris | 1 |
| *Erythemis* | Hagen, 1861, p. 168 | *peruviana* (Rambur) | 9 |
| *Erythrodiplax* | Brauer, 1868, pp. 368, 722 | *corallina* (Brauer) | 51 |
| *Fylgia* | Kirby, 1889, pp. 259, 312 | *amazonica* Kirby | 1 |
| *Gynothemis* | Calvert (in Ris, 1909, p. 34) | *venipunctata* Calvert | 4 |
| *Idiataphe* | Cowley, 1934, p. 243 | *longipes* (Hagen) | 3 |
| *Lepthemis* | Hagen, 1861, p. 160 | *vesiculosa* (Fabricius) | 1 |
| *Leucorrhinia* | Brittinger, 1850, p. 333 | *albifrons* (Burmeister) | 7 |
| *Libellula* | Linnaeus, 1758, p. 543 | *quadrimaculata* Linnaeus[3] | 25 |
| *Macrodiplax* | Brauer, 1868, pp. 366, 737 | *cora* (Brauer) | 1 |

[2]Includes species and subspecies; the figures in some cases are approximate.

[3]*Quadrimaculata* is listed as the genotype by Calvert (1901–1908, p. 206) and Ris (1910, p. 246); Kirby (1889, p. 284) and Muttkowski (1910, p. 135) list *depressa* Linnaeus as the genotype.

| | | | |
|---|---|---|---|
| *Macrothemis* | Hagen, 1868, p. 281 | *celaeno* (Selys) | 27 |
| *Miathyria* | Kirby, 1889, pp. 258, 269 | *simplex* (Rambur) | 2 |
| *Micrathyria* | Kirby, 1889, pp. 264, 303 | *didyma* (Selys) | 28 |
| *Misagria* | Kirby, 1889, pp. 259, 296 | *parana* Kirby | 1 |
| *Nannothemis* | Brauer, 1868, pp. 369, 726 | *bella* (Uhler) | 1 |
| *Nephepeltia* | Kirby, 1889, pp. 259, 310 | *phryne* (Perty) | 4 |
| *Oligoclada* | Karsch, 1889, p. 382 | *pachystigma* Karsch | 14 |
| *Orthemis* | Hagen, 1861, p. 160 | *ferruginea* (Fabricius) | 14 |
| *Pachydiplax* | Brauer, 1868, pp. 368, 722 | *longipennis* (Burmeister) | 1 |
| *Paltothemis* | Karsch, 1889, p. 362 | *lineatipes* Karsch | 1 |
| *Pantala* | Hagen, 1861, p. 141 | *flavescens* (Fabricius) | 2 |
| *Perithemis* | Hagen, 1861, p. 185 | *tenera* (Say) | 12 |
| *Planiplax* | Muttkowski, 1910, p. 169 | *erythropyga* (Karsch) | 4 |
| *Podothemis* | Ris, 1909, p. 27; 1911, p. 406 | *nemesis* Ris | 1 |
| *Pseudoleon* | Kirby, 1889, pp. 261, 274 | *superbus* (Hagen) | 1 |
| *Rhodopygia* | Kirby, 1889, pp. 265, 299 | *cardinalis* (Erichson) | 4 |
| *Scapanea* | Kirby, 1889, pp. 264, 298 | *frontalis* (Burmeister) | 1 |
| *Sympetrum* | Newman, 1833, p. 511 | *vulgatum* (Linnaeus) | 15 |
| *Tarnetrum* | Needham and Fisher, 1936, p. 114 | *illotum* (Hagen) | 5[4] |
| *Tauriphila* | Kirby, 1889, pp. 258, 268 | *australis* (Hagen) | 5 |
| *Tholymis* | Hagen, 1867, p. 221 | *tillarga* (Fabricius) | 1 |
| *Trapezostigma* | Hagen, 1849, p. 174 | *carolina* (Linnaeus) | 6 |
| *Uracis* | Rambur, 1842, pp. 26, 31 | *imbuta* (Burmeister) | 6 |
| *Zenithoptera* | Selys, 1869, p. 16 | *americana* (Linnaeus) | 2 |

Of the remaining 22 generic names, which do not appear in the key, some have been reduced to synonymy, some have been reduced to the rank of subgenus, and some genera have been renamed. A list of these names, together with the present status of each, is given below.

| *Genus* | *Reference* | *Present Status* |
|---|---|---|
| *Aino* | Kirby, 1890, p. 113 | = *Nannothemis* Brauer |
| *Belonia* | Kirby, 1889, pp. 261, 288 | subgenus of *Libellula* Linnaeus |
| *Coenotiata* | Buchecker, 1876, p. 10 | = *Leucorrhinia* Brittinger |
| *Diplax* | Charpentier, 1840, p. 12 | = *Sympetrum* Newman |
| *Eolibellula* | Kennedy, 1922, p. 111 | subgenus of *Libellula* Linnaeus |
| *Ephidiata* | Kirby, 1889, pp. 262, 283 | = *Idiataphe* Cowley |
| *Holotania* | Kirby, 1889, pp. 261, 288 | subgenus of *Libellula* Linnaeus |
| *Ladona* | Needham, 1897, p. 146 | subgenus of *Libellula* Linnaeus |
| *Leptetrum* | Newman, 1833, p. 511 | = *Libellula* Linnaeus |
| *Malamarptis* | Karsch, 1889, p. 380 | = *Dasythemis* Karsch |
| *Melanarptis* | Kirby, 1890, p. 183 | = *Dasythemis* Karsch |
| *Mesothemis* | Hagen, 1861, p. 170 | = *Erythemis* Hagen |
| *Neocysta* | Kirby, 1889, pp. 263, 300 | = *Orthemis* Hagen |
| *Neotetrum* | Kennedy, 1922, p. 111 | subgenus of *Libellula* Linnaeus |
| *Neothemis* | Karsch, 1889*a*, p. 256 | = *Nephepeltia* Kirby |
| *Nothifixis* | Navas, 1916, p. 2 | = *Miathyria* Kirby[5] |
| *Plathemis* | Hagen, 1861, p. 149 | subgenus of *Libellula* Linnaeus |
| *Platyplax* | Karsch, 1891, p. 268 | = *Planiplax* Muttkowski |
| *Potamothemis* | Kirby, 1889, pp. 257, 272 | = *Zenithoptera* Selys |
| *Pronomaja* | Förster, 1909, p. 225 | = *Uracis* Rambur |
| *Tramea* | Hagen, 1861, p. 143 | = *Trapezostigma* Hagen |
| *Urothemis* | Hagen, 1875, p. 89 | = *Uracis* Rambur |

[4]Includes *nigrocreatum* (Calvert), *illotum* (Hagen), *virgulum* (Selys), *gilvum* (Hagen), and *corruptum* (Hagen).

[5]Navas' genus has apparently been overlooked by later reviewers of the Libellulidae. This genus contains a single species, *Nothifixis laxa* Navas, which, on the basis of Navas' description, is apparently *Miathyria simplex* (Rambur). We are therefore considering *Nothifixis* Navas as a synonym of *Miathyria* Kirby.

## TABLE I

### Comparison of Terminologies of Odonate Wing Venation: The Longitudinal Veins

| Terminology Used in this Paper | | Other Terminologies | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Tillyard & Fraser | |
| Name | Abb. | Selys[6] | Kirby | Needham[7] | Tillyard 1917 | 1938–1940 | 1940 |
| costa | C | costa | costa | C | C | C | CA[8] |
| subcosta | Sc | subcosta | internodal radius | Sc | Sc | Sc | CP[9] |
| radius + media (wing base to arculus) | R+M | median | principal radius or subcostal nervure | R+M | R+M | R+M | R+M |
| first radius | $R_1$ | | | $R_1$ | R | $R_1$ | $R_1$ |
| radial sector[10] | Rs | upper sector of arculus | upper sector of arculus | $M_{1-2}$ | $M_{1-2}$ | Rs | Rs |
| second radius | $R_2$ | principal sector | subcostal radius | $M_1$ | $M_1$ | $R_2$ | $R_2$ |
| second radius intercalaries | $IR_{2a}$ | postnodal sector | | $M_{1a}$[11] | | $IR_2$ | $IR_2$ |
| | $IR_{2b}$ | | | apical planate | | | |
| third radius | $R_3$ | nodal sector | nodal sector | $M_2$ | $M_2$ | $R_3$ | $R_3$ |
| third radius intercalary[12] | $IR_3$ | subnodal sector | subnodal sector | Rs | Rs | $IR_3$ | $IR_3$ |
| radial supplement | Rspl | supplementary sector next below subnodal sector | | Rspl, Rpl[13] | Rspl | Rspl | Rspl |
| fourth and fifth radius | $R_{4+5}$ | median sector | upper sector of arculus | $M_3$ | $M_3$ | $R_{4+5}$ | $R_{4+5}$ |
| anterior media | MA | lower sector of arculus,[14] short sector[15] | lower sector of arculus | $M_4$ | $M_4$ | MA | MA |
| median supplement | Mspl | supplementary sector next below short sector | | Mspl, Mpl[16] | Mspl | Mspl | Mspl |
| posterior cubitus[17] | CuP | submedian, or upper sector of triangle | upper sector of triangle | $Cu_1$[18] | $Cu_1$ | $Cu_2$ | CuP |
| anal | A | postcosta | | A[19] | $A_1$ | A′ | A′ |
| first anal | $A_1$ | lower sector of triangle | lower sector of triangle | $Cu_2$ | $Cu_2$ | $A_1$ | AA |
| first anal accessory (hind wing) | $A_{1a}$ | | subbasal | $A_1$ | | | |
| anal supplement (hind wing) | Aspl | distal subbasal sector | sectors | bisector of anal loop[20] | Cuspl | Aspl[21] | Aspl[21] |
| second anal | $A_2$ | proximal sub-basal sector | | $A_2$[22] | $A_2$ | | |

[6]This system was used by Calvert (1901–1908) and many other writers up to the time of the introduction of the Comstock-Needham system.

[7]This is the Comstock-Needham system, based on studies of tracheation in the nymphal wing, which is used by most present workers (including Ris and Bartenef).

[8]Costalis anticus.

[9]Costalis posticus.

[10]The fused bases of Rs and MA form the upper portion of the arculus. In the Key Rs and MA, where they extend distad from the arculus, are referred to as the sectors of the arculus.

[11]Apical sector.

[12]The proximal part of this vein, from its origin at $R_{3+4}$ to the oblique crossvein, is termed the bridge by Needham, Ris, Bartenef, Tillyard (1917), and others.

[13]Radial planate; termed radial supplement by Ris and Bartenef.

[14]The basal portion, from the arculus to the triangle.

[15]The distal portion, from the triangle to the wing margin.

[16]Median planate; termed median supplement by Ris and Bartenef.

[17]The anterior branch of the cubitus appears in some fossil forms as a short vein at the base of the wing, but is lacking in modern forms.

[18]The portion distal to the triangle termed Cu; the basal portion termed Cu.

[19]Only from cu-a distad.

[20]Termed $A_3$ by Ris and Bartenef.

[21]Also called the midrib of the anal loop.

[22]Termed $A_3$ by Ris and Bartenef.

## TABLE II

### Comparison of Terminologies of Odonate Wing Venation: Crossveins, Cells, and Special Areas of the Wing

| Terminology Used in this Paper | | Other Terminologies | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Tillyard & Fraser | |
| Name | Abb. | Selys[22] | Kirby | Needham[24] | Tillyard 1917 | 1938–1939 | 1940 |
| antenodals | Ax | antecubitals | antenodals | An | Ax | Ax | Ax |
| postnodals | Px | postcubitals | postnodals | Pn | Px | Px | Px |
| nodus | N | nodus | nodus | n | N | N | N |
| subnodal crossvein | sn | subnodus | nodal cross nervure | sn | Sn | | |
| arculus | arc | arculus | arculus | arc | arc | arc | arc |
| bridge crossvein | bcv | | | Bq.[25] bcv | Bx | crossvein to the bridge | crossvein to the bridge |
| cubito-anal crossvein | cu-a | submedian crossvein | cross nervule in lower basal cell | Ac[26] | Cux | AC[26] | AC[26] |
| oblique crossvein | o | | | o[27] | o | | |
| brace vein[28] | | | | brace vein | Bc | | |
| triangle | t | triangle, discoidal triangle, or cardinal cell | triangle | t | t | discoidal cell | discoidal cell |
| subtriangle | st | internal triangle, subtriangle, or subtriangular space | subtriangular space | t'[29] | st, t', ti | s | s |
| supratriangle | ht | hypertrigonal or supratriangular space | supratriangular space | s, ht[30] | s, ht | h | h |
| discoidal field | df | posttriangular or discoidal field | posttriangular cells | | d | discoidal field | discoidal field |
| median cell | m | basilar space[31] | upper basal cell | m | median space | | |
| cubital cell | cu | median space[31] | lower basal cell | cu | cubito-anal space | | |
| anal loop | | | | anal loop | anal loop | anal loop | anal loop |
| sole of anal loop[32] | sole | | | sole | | | |
| heel of anal loop[33] | heel | | | heel[34] | | | |
| anal field (hind wing) | AP | | | cells behind loop[35] | | | |
| stigma | s | pterostigma | pterostigma | st | pt | pt | pt |
| membranule | mb | membranule | membranule | mb | mb | | |

[22]This system was used by Calvert (1901–1908) and many other writers up to the time of the introduction of the Comstock-Needham system.

[24]This is the Comstock-Needham system, based on studies of tracheation in the nymphal wing, which is used by most present writers (including Ris and Bartenef).

[25]Any bridge crossveins present in addition to the one always present were termed supplementary bridge crossveins (Bqs) by Ris and Bartenef.

[26]Anal crossing, the one crossvein always present in this space; additional crossveins were termed cubito-anal crossveins.

[27]Rs crossing over $M_2$.

[28]A slanting crossvein between $R_1$ and $R_2$ at the proximal end of the stigma, termed the stigmatic brace by some writers. This vein does not occur in the Libellulidae.

[29]Labelled ti by Ris and Bartenef.

[30]Labelled ht (hypertriangle) by Ris and Bartenef.

[31]Later Selys suggested calling the basilar space the median space, and the median space the submedian space; see Calvert, 1901–1908, p. 174, footnote.

[32]$A_{1a}$ from $A_1$ to the apex of the anal loop.

[33]The angle of separation of $A_{1a}$ from $A_1$.

[34]Termed the outer angle of the anal loop by Ris and Bartenef.

[35]Termed the anal field by Ris and Bartenef.

### THE KEY CHARACTERS

The principal characters appearing in the following key are those of the wings and venation, but it has been necessary at some points to use other characters (of the head, legs, prothorax, abdomen, and genitalia).

*Venational Characters* (figs. 1–36, 52).—The terminology of wing venation used in this paper is essentially that of Tillyard and Fraser (1938–1940). This terminology is similar to that of the Comstock-Needham system, which is widely used by present-day students of the Odonata, but differs in the interpretation of some of the principal longitudinal veins. According to the Comstock-Needham system the radial sector is unbranched and crosses over the two anterior branches of the four-branched media (with the subnodal and oblique crossveins representing the points of crossing over), the cubitus is two-branched, and the cubital and anal veins arise together at the base of the wing. Recent studies of the wing venation in fossil dragonflies by Tillyard, Fraser, Carpenter, and others indicate that (1) the radial sector is three-branched and does not cross over the media, (2) only a single branch (the anterior) of the media occurs in the Odonata, (3) the first branch of the cubitus does not occur in modern Odonata, but is represented in certain fossil types by a short vein at the base of the wing, and (4) the anal vein arises from the wing base separate from the cubitus. In the present system of terminology, therefore, certain of the Comstock-Needham terms are changed: $M_1$ becomes $R_2$, $M_2$ becomes $R_3$, Rs becomes $IR_3$ (intercalary of $R_3$), $M_3$ becomes $R_{4+5}$, $M_4$ becomes MA (anterior media), $Cu_1$ becomes CuP (posterior cubitus), and the anal crossing (Ac) becomes the cubito-anal crossvein (cu-a). The "bridge" of the Comstock-Needham system is here regarded simply as the basal portion of $IR_3$, though we have, for convenience, retained the name bridge crossvein for the crossvein above the "bridge." The terminology of odonate wing venation used in this paper is compared with other terminologies in Tables I and II.

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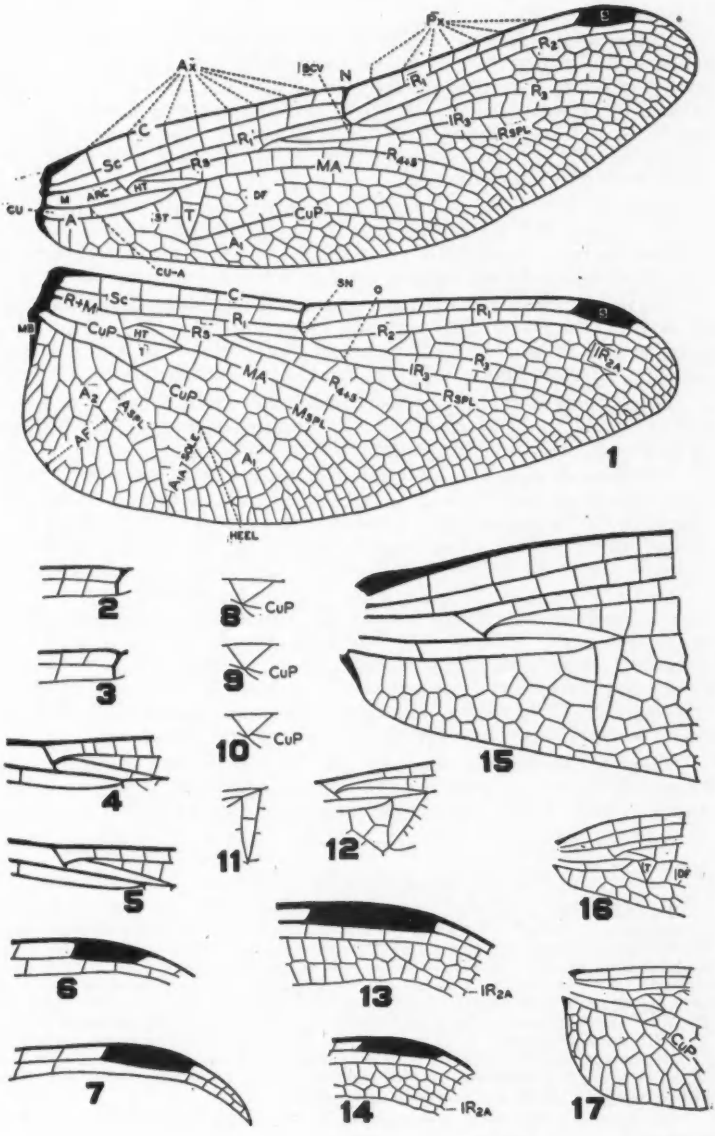
### EXPLANATION OF PLATE I

FIGURE 1, wings of *Sympetrum rubicundulum* (Say), showing venational characters. 2, last antenodal in front wing complete; 3, last antenodal in front wing incomplete. 4, sectors of arculus in front wing not stalked (*Libellula*); 5, sectors of arculus in front wing stalked (*Orthemis*). 6, stigma with ends not parallel (*Trapezostigma*). 7, stigma with ends parallel; no crossveins, and a very long cell, behind stigma (*Pachydiplax*). 8–10, CuP in hind wing: 8, arising at anal angle of triangle; 9–10, separated from anal angle of triangle. 11–12, triangle in front wing: 11, costal side one-third as long as proximal side, triangle crossed (*Erythemis*); 12, costal side more than half as long as proximal side, triangle crossed (*Celithemis*). 13–14, origin of $IR_{2a}$: 13, under middle third of stigma (*Libellula*, subgenus *Holotania*); 14, under proximal fourth of stigma (*Libellula*, subgenus *Ladona*). 15–16, base of front wings: 15, subtriangle indistinct, 4 cell rows in discoidal field (*Trapezostigma*); 16, triangle free, costal side of triangle broken, 1 cell row in discoidal field (*Nannothemis*). 17, base of hind wing: anal loop indistinct, CuP arising at anal angle of triangle (*Nannothemis*).

All figures drawn with projection apparatus; magnification about 3.75 ×. Abbreviations as in tables I and II.


Ax
IScv
N
C
Sc
R1
Rs
MA
R4+5
IR3
Rspl
M
Arc
HT
Cu
A
St
T
Df
CuP
A1
CU-A
R+M
SN
MB
IR2A
A2
Aspl
Mspl
Ax
Ax1
HEEL
1
2
3
4
5
6
7
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15
16
17

Only a few of these venational characters are likely to cause difficulty to users of the key:

*Sectors of the Arculus Stalked or Not Stalked.*—If the length of the union of the two sectors distad of the arculus is approximately equal to the length of the upper piece of the arculus (fig. 5), the sectors may be said to be stalked; if the length of this union is no greater than the length of the lower piece of the arculus (fig. 4), the sectors may be said to be not stalked. Intermediate conditions should key out correctly with either interpretation.

*Shape of $R_3$.*—If $R_3$ is shaped as shown in figures 24–25, it is said to be undulate; if it is like that shown in figure 27 (or even less curved), it is said to be not undulate; if it is shaped like that shown in figure 26, the specimen should key out correctly with either interpretation.

*Shape of Aspl in Hind Wing.*—If the angle of this vein at the level of the heel is similar to the conditions shown in figures 1, 18, 19, or 22, it may be said to be bent at the level of the heel; if this vein is shaped like that shown in figure 20, it may be said to be straight or nearly so.

*Development of Mspl.*—A condition similar to that shown in figure 35 is interpreted as Mspl indistinct; a condition similar to those shown in figures 31, 33, and 34, is interpreted as Mspl distinct.

*Cell Rows Between $IR_3$ and Rspl, and Between MA and Mspl.*—These supplements are usually arched, and if they subtend two cell rows for a distance of at least two cells in their central portion, even though only one cell row is subtended at their ends (as in fig. 33), there may be said to be two cell rows between the principal vein and its supplement.

*Origin of CuP in the Hind Wing.*—If the origin of the CuP in the hind wing is like that shown in figure 8, CuP may be said to arise at the anal angle of the triangle; if it is like those shown in figures 9 and 10, or if CuP arises farther from the apex of the triangle, it may be said to be separated from the anal angle of the triangle. Specimens in which the condition of the CuP is intermediate between those shown in figures 8 and 9 should key out correctly with either interpretation.

*Shape of the Stigma.*—Stigmas like those in figures 7 and 13 may be said to have their ends parallel; stigmas like those shown in figures 6 and 23 may be said to have their ends not parallel.

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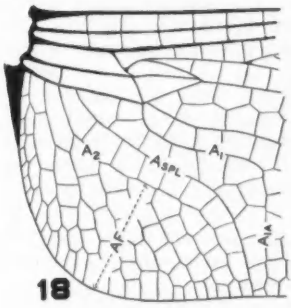
## EXPLANATION OF PLATE II

FIGURES 18–22, wing bases: 18, anal loop open posteriorly and extending to wing margin (*Tholymis*); 19, 3 cell rows in anal field parallel to $A_2$, Aspl strongly bent at level of heel (*Dythemis*); 20, triangle and subtriangle in front wing free, costal side of triangle in front wing as long as proximal side, Aspl in hind wing straight or nearly so (*Perithemis*); 21, (hind wing), base of triangle distad of arculus, triangle and supratriangle crossed, 4 cubito-anal crossveins (*Uracis*); 22, 2 cell rows in anal field (*Macrothemis*). 23–27, distal half of front wings: 23, $IR_2b$ well developed, with most of the cells above it elongated vertically (*Miathyria*); 24, $R_3$ very undulate (*Pantala*); 25, $R_3$ moderately undulate (*Libellula*); 26, $R_3$ very slightly undulate, or, this condition might be interpreted as not undulate (*Dythemis*); 27, $R_3$ not undulate (*Pachydiplax*).

All figures drawn with projection apparatus; magnification of figures 18–23 about 3.75 ×, of figures 24–27 about 2.3 ×. Abbreviations as in Tables I and II.



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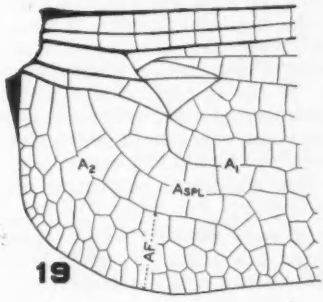

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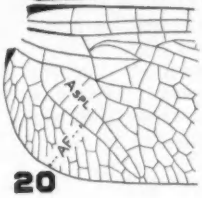

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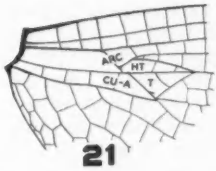

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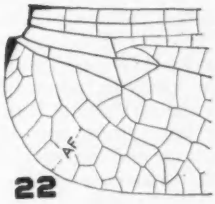

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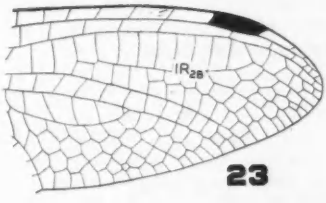

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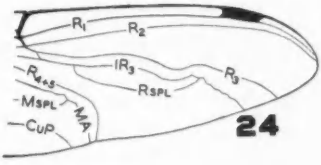

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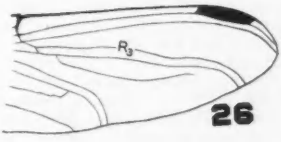

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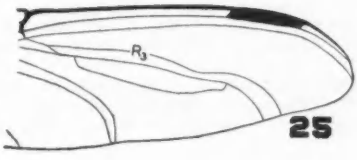

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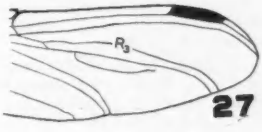

27

*Number of Bridge Crossveins.*—If at least three of the four wings have the same number of bridge crossveins, this number should be used in keying the specimen; if two wings have one number and the other two wings have another number, the specimen should key out correctly using either number of crossveins.

In the case of venational characters where there is a possibility of misinterpretation, reference is made to figures which should clarify the point. In case of doubt, or where the right and left wings differ, the specimen should key out correctly with either interpretation; in couplets where additional characters are given, they may be used to decide the point.

*Head Characters.*—Only three head characters are used, and these only a few times: (1) whether or not the eyes are contiguous dorsally, (2) the length of the dorsal contact of the eyes, and (3) the color of the face. No difficulty should be encountered in evaluating these characters.

*Leg Characters* (figs. 45–50, 53–59).—The principal leg character used is the nature of the spination on the outer angle of the hind femur. Typically these spines are slender, erect or slanting somewhat distad, and either increase in length dorsally (fig. 48) or are all short except the last (fig. 45). In some genera (*Brechmorrhoga, Macrothemis,* and *Scapanea*) sexual dimorphism occurs, with the female having a more or less typical spination and the male having the spines shorter and stouter and directed proximad (figs. 49–50). In some genera (*Erythemis* and *Rhodopygia*) the spines on the basal portion of the femur are markedly different from those on the distal portion (figs. 46–47). The size of the tooth on the tarsal claw varies considerably in different genera (figs. 53–59), and is occasionally used in the key. The taxonomic value of leg characters in the Libellulidae has been discussed by Montgomery (1940).

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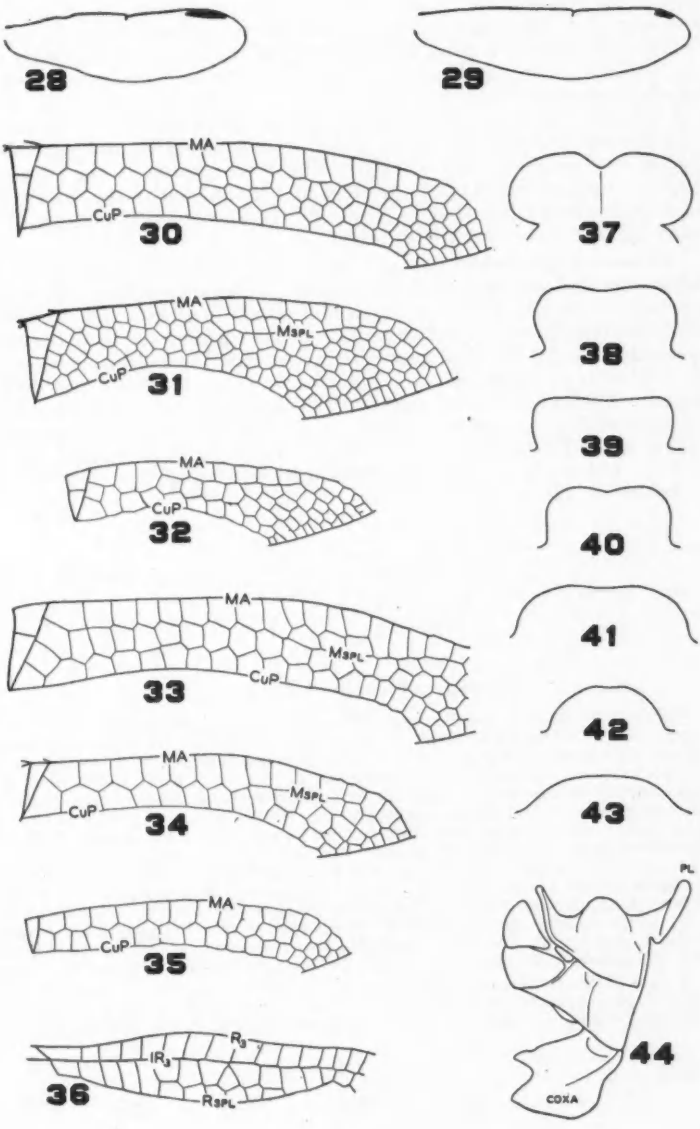
EXPLANATION OF PLATE III

FIGURES 28–29, front wings: 28, costa with a concave indentation between base and nodus (*Zenithoptera*); 29, nodus distad of middle of wing (*Macrothemis*). 30–35, discoidal field of front wings: 30, 3 cell rows, the field parallel-sided (*Orthemis*); 31, 4 cell rows, the field widened distally; Mspl distinct with 2 cell rows between it and MA (*Libellula*); 32, 2 cell rows, the field widened distally (*Leucorrhinia*); 33, 3 cell rows, Mspl distinct with 2 cell rows between it and MA (*Paltothemis*); 34, 2 cell rows, Mspl fairly distinct with 1 cell row between it and MA, the field slightly widened distally (*Brechmorrhoga*); 35, 2 cell rows, Mspl indistinct (*Macrothemis*). 36, 2 cell rows between $IR_3$ and Rspl (*Paltothemis*). 37–43, posterior lobes of prothorax, dorso-anterior view: 37–38, lobe narrowed at base (37—*Sympetrum*, 38—*Erythrodiplax*); 39, this form of the prothoracic lobe might be interpreted either as narrowed at base, or as quadrate and not narrowed at base (*Erythrodiplax*); 40–43, lobe not narrowed at base; 40, lobe quadrate (*Erythrodiplax*); 41–43, lobe rounded (41—*Trapezostigma*, 42—*Erythrodiplax*, 43—*Macrodiplax*). 44, lateral view of prothorax of *Sympetrum*, showing the erect posterior lobe (PL).

Figures 28–36 drawn with projection apparatus; magnification about 1.8× for figures 28–29, and about 3.75 × for figures 30–36; figures 37–44 drawn with camera lucida, magnification about 10×. Abbreviations of venational characters as in Tables I and II.


28
29
MA
CuP
30
37
MA
MSPL
CuP
31
38
39
MA
CuP
32
40
MA
MSPL
CuP
33
41
42
MA
CuP
MSPL
34
43
MA
CuP
35
PL
R3
IR3
36
RSPL
44
COXA

*Thoracic Characters* (figs. 37–44).—The only thoracic character used is the shape of the posterior lobe of the prothorax. This lobe is best seen in a dorso-anterior view; in some specimens it can be seen clearly only after the head is removed. If the shape of this lobe is like either of those in figures 37–38 it may be said to be narrowed basally; lobes with this shape are usually more or less erect (as in fig. 44) and fringed with long hairs. If the lobe is shaped like any of those in figures 40–43 it may be said to be not widened distally, and quadrate (fig. 40) or rounded (figs. 41–43). The more narrowed the lobe is distally, the less likely it is to be erect and fringed with long hairs. If the lobe is shaped like that in figure 39, the specimen should key out correctly with either interpretation.

*Abdominal Characters* (figs. 51, 60–72).—The principal abdominal characters used are those of the genitalia. In some genera the hamules are divided apically into two (inner and outer) branches (figs. 64–66), and hence may be said to be two-parted; in other genera the outer branch is greatly reduced or absent, and only the inner branch is developed (figs. 62–63), in which case the hamules may be said to be not two-parted. The vulvar lamina may vary from a slight bilobed thickening of the caudal margin of the eighth sternite (fig. 69) to a long trough-shaped caudad extension of this sternite which projects ventrad (figs. 70–71). Other abdominal characters used in the key are illustrated by figures 51, 60–61, and 72.

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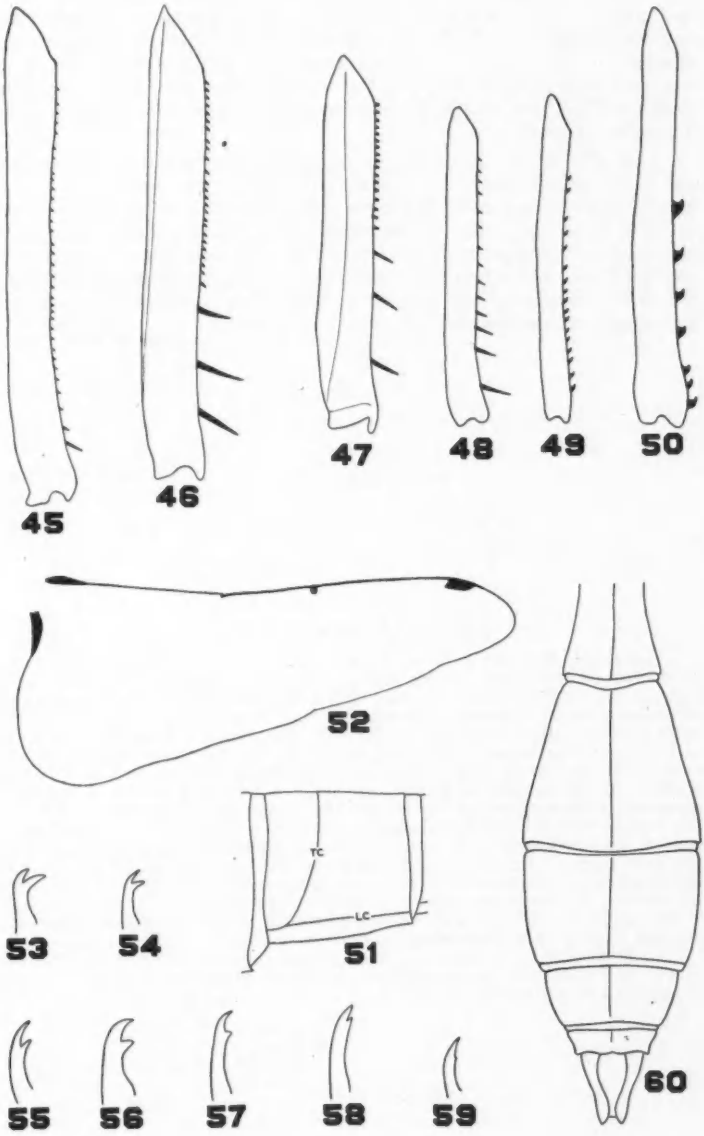
EXPLANATION OF PLATE IV

FIGURES 45–50, hind femora (figure 47 is of middle femur), showing spination on outer angle: 45, spines all short except the last (*Dythemis*); 46, spines on basal half short and of about equal length, three large spines on distal half (*Erythemis*); 47 (middle femur), spines on basal two-thirds short, stout, blunt-tipped, and of approximately uniform length, those on distal third long and slender (*Rhodopygia*); 48, spines slender, gradually increasing in length distally (*Erythrodiplax*); 49–50, spines short, stout, and directed proximad (49—*Macrothemis* ♂, 50—*Brechmorrhoga* ♂). Abdominal segment (lateral view) showing lateral (LC) and transverse (TC) carinae (segment 4 of *Perithemis*). 52, hind wing noticeably broadened at base (*Trapezostigma*). 53–59, tarsal claws: 53, tooth longer than tip of claw (*Macrothemis*); 54, tooth nearly as long as tip of claw (*Macrothemis*); 55–57, tooth normal (55—*Sympetrum*, 56—*Scapanea*, 57—*Dythemis*); 58, tooth small and near tip of claw (*Oligoclada*); 59, tooth very small, little more than a notch (*Oligoclada*). 60, segments 7–9 of male strongly widened (*Scapanea*).

Figure 52 drawn with projection apparatus, other figures drawn with camera lucida; magnification of figures 45–50 about 7×, of figure 51 about 10×, of figure 52 about 1.8 ×, of figures 53–59 about 18×, of figure 60 about 4×.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TC
LC
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60

While it is hoped that this key will be accurate for practically every specimen, it must be recognized that in every genus and species there may be a few individuals with abnormal characteristics. Many such characteristics have been taken into account in the preparation of this key, but undoubtedly some of the less common ones have been overlooked. This key should be accurate for 95 per cent or more of the material it covers.

This key is not intended to represent phylogenetic relationships, but is intended merely to aid in identification. In taking into account intrageneric variations it has been necessary to key out many genera at more than one point; *Erythrodiplax*, the largest genus in this fauna, keys out at fourteen points in the key. Because many couplets are reached from more than one preceding couplet, the couplets have been numbered (following the scheme proposed by Williamson) so that the key can be worked backward as well as forward.

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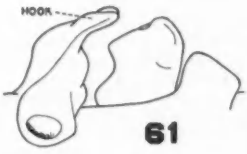
EXPLANATION OF PLATE V

FIGURES 61–66, lateral views of male genitalia on segment 2: 61, a pair of prominent ventral hooks on segment 1 (*Libellula*, subgenus *Plathemis*); 62–63, hamules not 2-parted, only the inner branch (IB) developed (62—*Dythemis*, 63—*Oligoclada*); 64–66, hamules 2-parted; 64, inner branch (IB) much larger than outer branch (OB) and projecting ventrad (*Dasythemis*); 65, inner branch (IB) as large as outer branch (OB) and projecting ventrad (*Dasythemis*); 66, inner branch (IB) smaller than outer branch (OB) and projecting ventro-mesad (*Erythrodiplax*). 67–72, terminal abdominal segments of female: 67, sides of segment 8 expanded (*Orthemis*); 68, vulvar lamina (VL) in ventral view small and bilobed (*Dythemis*); 69, segment 10 prolonged distally on ventral side to about opposite apex of superior appendages, vulvar lamina in ventral view (the wavy line below the large figure) little more than a bilobed thickening of the caudal margin of the eighth sternite (*Dasythemis*); 70–71, vulvar lamina (VL) scoop-shaped and projecting ventrad (*Erythrodiplax;* these two figures represent the extremes of variation in the size of the vulvar lamina in this genus); 72, vulvar lamina and sternum of segment 9 elongate and extending caudad beyond apex of abdomen (*Uracis*).

All figures drawn with camera lucida; magnification of figures 61–62, 64–65, 68, and 70–72, about 10 ×; magnification of figures 63 and 66 about 18 ×, of figure 67 about 3.5 ×, of figure 69 about 7 ×.

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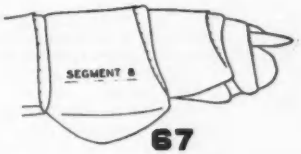


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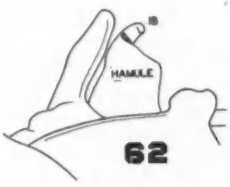


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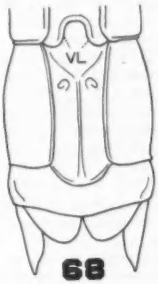


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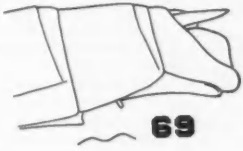

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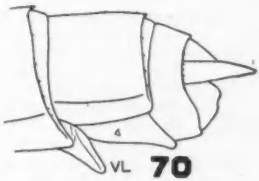


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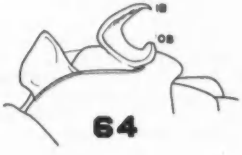


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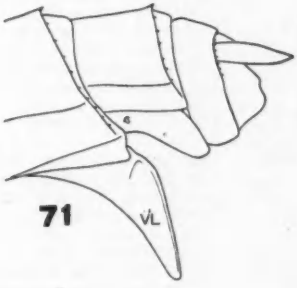


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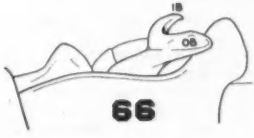


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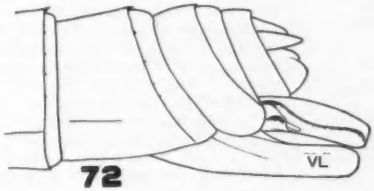


72

KEY TO THE NEW WORLD GENERA OF LIBELLULIDAE

1. Anal loop indistinct (fig. 17) ..... 2
1'. Anal loop well developed, sac-like or foot-shaped ..... 3
2(1). One cubito-anal crossvein in hind wing; CuP in hind wing usually arising at anal angle of triangle (fig. 17); eastern United States, and Canada ..... **Nannothemis**
2'. Two or three cubito-anal crossveins in hind wing; CuP in hind wing widely separated from anal angle of triangle; South America (French Guiana) ..... **Argyrothemis**
3(1'). Costa of front wing with a concave indentation between base and nodus (fig. 28) ..... 4
3'. Costa of front wing without a concave indentation between base and nodus (figs. 1, 29) ..... 5
4(3). Eyes separated; supratriangle crossed ..... **Diastatops**
4'. Eyes contiguous; supratriangle usually free ..... **Zenithoptera**
5(3'). Three cubito-anal crossveins in front wing, 2 in hind wing, 1–3 bridge crossveins; triangles with 2 or more crossveins; posterior lobe of prothorax very small, its distal margin weakly arched; 20 or more antenodals in front wing, some irregular; arculus between first and second antenodals; hind wing 47 mm., with a deep black basal spot extending halfway to nodus; South America ..... **Antidythemis**
5'. Not as above ..... 6
6(5'). Last antenodal in front wing complete (fig. 2) ..... 7
6'. Last antenodal in front wing incomplete (figs. 1, 3) ..... 43
7(6). One bridge crossvein ..... 8
7'. Two or more bridge crossveins ..... 28
8(7). Arculus in hind wing between first and second antenodals ..... 9
8'. Arculus in hind wing opposite or distad of second antenodal ..... 26
9(8). $R_3$ undulate (as in fig. 24 or 25) ..... 10
9'. $R_3$ not undulate (as in fig. 27) ..... 12
10(9). Sectors of arculus in front wing stalked (fig. 5); 3 (rarely 4) cell rows in discoidal field of front wing, the field parallel-sided or slightly narrowed distally (fig. 30); 1 (rarely 2) cell rows between MA and Mspl in front wing ..... 11
10'. Sectors of arculus in front wing not stalked (fig. 4); 4 cell rows in discoidal field of front wing, the field widened distally (fig. 31); 2 cell rows between MA and Mspl in front wing (fig. 31) ..... **Libellula**
11(10). Hamules 2-parted (as in fig. 66); sides of segment 8 in female expanded (fig. 67) ..... **Orthemis**
11'. Hamules not 2-parted (fig. 62); sides of segment 8 in female not expanded ..... **Dythemis**
12(9'). Usually no crossveins behind stigma (fig. 7); if there is a crossvein behind the stigma it is behind the distal fourth of the stigma; a very long cell behind stigma ..... **Pachydiplax**
12'. One or more crossveins behind stigma, usually with at least one crossvein behind proximal half of stigma; cells behind stigma usually of normal length (figs. 1, 6, 13, 14) ..... 13
13(12'). CuP in hind wing arising at anal angle of triangle (fig. 8) ..... 14
13'. CuP in hind wing separated from anal angle of triangle (figs. 9–10) ..... 20
14(13). Triangle in front wing free ..... 15
14'. Triangle in front wing crossed ..... 18
15(14). Posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38) ..... 16
15'. Posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (figs. 40–43) ..... 17
16(15). Aspl in hind wing bent at level of heel (as in fig. 1, 18, 19, or 22) ..... 35
16'. Aspl in hind wing straight or nearly so (as in fig. 20) ..... 89
17(15'.) Mspl in front wing very distinct; 5–6 rows of cells in anal field of hind wing; posterior lobe of prothorax small, its distal margin weakly arched (fig. 43) ..... **Macrodiplax**

17'. Mspl in front wing usually indistinct; 2–4 (rarely more) rows of cells in anal field of hind wing; posterior lobe of prothorax larger, rounded or quadrate (figs. 40, 42) ..... 99

18(14'). Posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (figs. 40–43) ..... 19

18'. Posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38) ..... 34

19(18). Two to three cell rows in discoidal field of front wing; ends of stigma parallel (as in fig. 7 or 14); a distinct subtriangle in front wing of 1–4 (rarely more) cells; hind wing not noticeably broadened at base (as in fig. 1) ..... **Erythrodiplax**

19'. Four cell rows in discoidal field of front wing (fig. 15); ends of stigma not parallel (fig. 6); subtriangle in front wing not distinct, several cells in this area of wing (fig. 15); hind wing noticeably broadened at base (fig. 52) ..... **Trapezostigma**

20(13'.) Posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38) ..... 21

20'. Posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (figs. 40–43) ..... 25

21(20). Triangle in front wing free ..... 22

21'. Triangle in front wing crossed ..... 35

22(21). Hamules 2-parted (figs. 64–66); vulvar lamina variable; United States and Canada ..... 23

22'. Hamules not 2-parted (fig. 63); vulvar lamina very short and not projecting ventrad; Mexico to South America ..... 24

23(22). Costal side of triangle in front wing more than half as long as proximal side (fig. 32); vulvar lamina not projecting ventrad; face white, **Leucorrhinia**

23'. Costal side of triangle in front wing less than half as long as proximal side; vulvar lamina as long as segment 9, projecting ventrad (fig. 71); face not entirely white ..... **Erythrodiplax**

24(22'). Tooth on tarsal claw small and near tip of claw (fig. 58), or very small, little more than a notch (fig. 59) ..... 95

24'. Tooth on tarsal claw larger and nearer middle of claw (as in fig. 55), **Podothemis**

25(20'). Inner branch of hamule as large as (fig. 65) or larger than (fig. 64) outer branch; vulvar lamina small, one-third as long as segment 9 or less, in ventral view more or less bilobed (fig. 69); segment 10 in female prolonged distally on ventral side to about opposite apex of superior appendages (fig. 69) ..... **Dasythemis**

25'. Inner branch of hamule smaller than outer branch (as in fig. 66); vulvar lamina larger, one-third as long as segment 9 or longer, in ventral view with apex rounded (figs. 70–71); segment 10 in female not prolonged distally on ventral side ..... 99

26(8'). $R_3$ not undulate (fig. 27) ..... 27

26'. $R_3$ undulate (as in fig. 24 or 25) ..... 29

27(26). Two or more cubito-anal crossveins in hind wing ..... 36

27'. One cubito-anal crossvein in hind wing ..... 37

28(7'). $R_3$ undulate (figs. 24–25) ..... 29

28'. $R_3$ not undulate (fig. 27) ..... 30

29 (26', 28). Discoidal field of front wing parallel-sided or somewhat narrowed distally (fig. 30); sectors of arculus in front wing stalked (fig. 5); no supratriangular crossveins; usually only 1 cubito-anal crossvein in hind wing ..... **Orthemis**

29'. Discoidal field of front wing widened distally (fig. 31); sectors of arculus in front wing not stalked (fig. 4); supratriangular crossveins usually present; usually 2 or more cubito-anal crossveins in hind wing ..... **Libellula**

30(28'). Arculus in hind wing between first and second antenodals ..... 31

30'. Arculus in hind wing opposite or distad of second antenodal ..... 42

31(30). Triangle in front wing free ..... 32

31'. Triangle in front wing crossed....34
32(31). Costal side of triangle in front wing broken, usually near middle (as in fig. 16); CuP in hind wing usually separated from anal angle of triangle (figs. 9–10); 1–2 cell rows in discoidal field of front wing....33
32'. Costal side of triangle in front wing straight; CuP in hind wing variable; 2–3 cell rows in discoidal field of front wing....88
33(32). One cell row in discoidal field of front wing (as in fig. 16); wings hyaline, or with a very small basal spot not extending beyond first antenodal, **Nephepeltia**
33'. Two cell rows in discoidal field of front wing (as in figs. 32, 34, and 35); hind wing with a reddish brown basal spot which extends nearly to nodus....**Edonis**
34(18', 31'). Aspl in hind wing bent at level of heel (figs. 1, 18, 19, 22)....35
34'. Aspl in hind wing straight or nearly so (fig. 20)....89
35(16, 21', 34). Face white; costal side of triangle in front wing more than half as long as proximal side (fig. 32); central and northern United States, and Canada....**Leucorrhinia**
35'. Face not white; costal side of triangle in front wing half as long as proximal side, or less; eastern and central United States to South America....114
36(27). Hind wing 20–26 mm....37
36'. Hind wing 29–35 mm....42
37(27', 36). Males....38
37'. Females....40
38(37). Hamules 2-parted (figs. 64–66); 1–3 cell rows in discoidal field of front wing....39
38'. Hamules not 2-parted; 1 cell row in discoidal field of front wing....**Elga**
39(38). Inner branch of hamule much smaller than outer branch, projecting ventro-mesad, and scarcely visible in profile....**Erythrodiplax**
39'. Inner branch of hamule as large as (fig. 65) or larger than (fig. 64) outer branch, projecting ventrad beyond outer branch, and easily visible in profile....**Dasythemis**
40(37'). Vulvar lamina scoop-shaped, one-fourth as long as segment 9 or longer, and projecting ventrad (figs. 70–71); segment 10 not prolonged distally on ventral side....**Erythrodiplax**
40'. Vulvar lamina poorly developed, little more than a bilobed thickening of the caudal margin of the eighth sternite, and not projecting ventrad; segment 10 usually prolonged distally on ventral side to about opposite apex of superior appendages (fig. 69)....41
41(40'). Nine antenodals in front wing; anal loop with 8–12 cells; usually 1 cell row in anal field....**Elga**
41'. Ten or more antenodals in front wing; anal loop with 4–15 cells; 1–2 cell rows in anal field....**Dasythemis**
42(30', 36'). Two cubito-anal crossveins in hind wing; CuP in hind wing separated from anal angle of triangle (figs. 9–10); triangle in hind wing free or crossed....**Cannaphila**
42'. Three cubito-anal crossveins in hind wing; CuP in hind wing arising at anal angle of triangle (fig. 8); triangle in hind wing crossed. **Misagria**
43(6'). Anal loop open posteriorly and extending to wing margin (as in fig. 17 or 18)....44
43'. Anal loop closed posteriorly and not extending to wing margin (figs. 1, 19, 20, 22)....45
44(43). Hind wing 35–40 mm.; 3 cell rows in discoidal field of front wing; Mexico and West Indies to northern South America....**Tholymis**
44'. Hind wing 14–16 mm.; 1–2 cell rows in discoidal field of front wing; eastern United States, and Canada....**Nannothemis**
45(43'). $R_3$ undulate (figs. 24–25)....46
45'. $R_3$ not undulate (fig. 27)....53
46(45). One bridge crossvein....47
46'. Two or more bridge crossveins....52
47(46). Mspl indistinct, or, if distinct, then usually only 1 cell row between it and MA (figs. 34–35)....48
47'. Mspl distinct, with 2 or more cell rows between it and MA, at least in front wing (fig. 33)....50

48(47). A transverse carina on segment 5 (as in fig. 51); $R_3$ very undulate (fig. 24); base of hind wing noticeably broadened (as in fig. 52), with 8 or more rows of cells in anal field ..... **Pantala**

48'. No transverse carina on segment 5; $R_3$ moderately to slightly undulate (figs. 25–26); base of hind wing not noticeably broadened (as in fig. 1) with 2–5 rows of cells in anal field (as in fig. 19) ..... 49

49(48'). Discoidal field of front wing with 2 cell rows, at least for a distance of three or more cells (fig. 34); base of triangle in hind wing usually slightly proximad of arculus; triangle in front wing free or crossed; spines on outer angle of hind femur of male short, stout, and directed proximad (fig. 50) ..... **Brechmorrhoga**

49'. Discoidal field of front wing with 3 cell rows, or rarely with 2 rows for a distance of one or two cells; base of triangle in hind wing usually opposite arculus; triangle in front wing crossed; spines on outer angle of hind femur of male variable ..... 81

50(47'). Postnodal portion of wings hyaline; ends of stigma not parallel; triangle in hind wing free ..... **Paltothemis**

50'. Postnodal portion of wings with some dark coloration; ends of stigma parallel; triangle in hind wing free or crossed ..... 51

51(50'). $IR_{2a}$ arising under proximal end of stigma; wings with area between nodus and stigma largely black; triangle in hind wing crossed, ..... **Pseudoleon**

51'. $IR_{2a}$ arising under middle of stigma; wing color not as above; triangle in hind wing free or crossed ..... **Libellula**

52(46'). Ends of stigma not parallel ..... **Paltothemis**

52'. Ends of stigma parallel ..... **Libellula**

53(45'). CuP in hind wing arising at anal angle of triangle (fig. 8) ..... 54

53'. CuP in hind wing separated from anal angle of triangle (figs. 9–10) ..... 92

54(53). Triangle in front wing free ..... 55

54'. Triangle in front wing crossed ..... 63

55(54). One bridge crossvein ..... 56

55'. Two or more bridge crossveins ..... 62

56(55). Posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (figs. 40–43) ..... 57

56'. Posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38) ..... 88

57(56). Mspl distinct in front wing (figs. 33–34) ..... 58

57'. Mspl not distinct in front wing (fig. 35) ..... 59

58(57). Subtriangle in front wing 1-celled; costal side of triangle in front wing more than half as long as proximal side; sectors of arculus in front wing not stalked (as in fig. 4) ..... **Idiataphe**

58'. Subtriangle in front wing 2- or 3-celled; costal side of triangle in front wing less than half as long as proximal side; sectors of arculus in front wing stalked (as in fig. 5) ..... 77

59(57'). $IR_{2b}$ well developed, with most of the cells above it elongated vertically (fig. 23); ends of stigma not parallel (fig. 23) ..... **Miathyria**

59'. $IR_{2b}$ not developed, usually no vertically elongated cells in this section of wing; ends of stigma usually parallel ..... 60

60(59'). Nodus in front wing distad of middle of wing (fig. 29) ..... 61

60'. Nodus in front wing in approximately the middle of wing (as in fig. 1) ... 99

61(60). Discoidal field of front wing slightly widened distally (fig. 34), ..... **Brechmorrhoga**

61'. Discoidal field of front wing parallel-sided or narrowed distally (fig. 35) .. 98

62(55'). Aspl in hind wing straight or nearly so (fig. 20); posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38); costal side of triangle in front wing half as long as proximal side, or longer ..... 89

62'. Aspl in hind wing bent at level of heel (as in fig. 1, 18, 19, or 22); posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (as in figs. 40–42); costal side of triangle in front wing usually less than half as long as proximal side ..... **Micrathyria**

63(54'). One bridge crossvein ..... 64
63'. Two or more bridge crossveins ..... 84
64(63). Arculus in front wing between first and second antenodals ..... 65
64'. Arculus in front wing opposite or distad of second antenodal ..... 72
65(64). Posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38) ..... 66
65'. Posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (figs. 40–43) ..... 75
66(65). Aspl in hind wing bent at level of heel (figs. 1, 18, 19, 22) ..... 67
66'. Aspl in hind wing straight or nearly so (fig. 20) ..... 89
67(66). Sectors of arculus in front wing stalked (as in fig. 5) ..... 68
67'. Sectors of arculus in front wing not stalked (as in fig. 4) ..... 117
68(67). One cell row between $IR_3$ and Rspl (fig. 1) ..... 69
68'. Two cell rows between $IR_3$ and Rspl (as in fig. 36) ..... 70
69(68). Discoidal field of front wing parallel-sided or narrowed distally (fig. 1); usually no lateral keel on segment 9 ..... 71
69'. Discoidal field of front wing usually slightly widened distally; a lateral keel on segment 9 ..... 103
70(68'). Discoidal field of front wing slightly widened distally; 12½ or more antenodals in front wing; costal side of triangle in front wing less than one-third as long as proximal side (as in fig. 1b) ..... **Lepthemis**
70'. Discoidal field of front wing parallel-sided or slightly narrowed distally (fig. 1); 10½ or fewer antenodals in front wing; costal side of triangle in front wing more than one-third as long as proximal side (fig. 1) ..... 71
71(69, 70'). A transverse carina on segment 4, at least in female (as in fig. 51); United States, Mexico, Central America, and South America, **Tarnetrum**
71'. No transverse carina on segment 4; North America south to Mexico, **Sympetrum**
72(64') One cubito-anal crossvein in hind wing ..... 73
72'. Two or more cubito-anal crossveins in hind wing ..... 82
73(72). Posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38) ..... 74
73'. Posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (figs. 40–43) ..... 76
74(73). Hind wing 20–28 mm.; spines on hind and middle femora of both sexes slender, gradually increasing in length distally (fig. 48) .. **Erythrodiplax**
74'. Hind wing 35–40 mm.; spines on basal two-thirds of middle femur of male short, stout, blunt-tipped, and of approximately uniform length, those on distal third long and slender (fig. 47); spines on basal half of outer angle of hind femur of male very short, those on distal half long and slender ..... **Rhodopygia**
75(65'). Four cell rows in discoidal field of front wing (fig. 15); base of hind wing broad (fig. 52), with many rows of cells in anal field; ends of stigma not parallel (fig. 6) ..... **Trapezostigma**
75'. Two or three cell rows in discoidal field of front wing; stigma and base of hind wing variable ..... 76
76(73', 75'). Two cell rows in discoidal field of front wing, at least for a distance of three cells (figs. 34–35) ..... 77
76'. Three cell rows in discoidal field of front wing (figs. 1, 30, 33), or rarely with 2 rows for a distance of one or two cells ..... 78
77(58', 76). Nodus in front wing distad of middle of wing (as in fig. 29); base of triangle in hind wing usually slightly proximad of arculus; spines on outer angle of hind femur of male short, stout, and directed proximad (fig. 50) vulvar lamina small, bilobed, and not projecting ventrad (as in fig. 68 or 69) ..... **Brechmorrhoga**
77'. Nodus in front wing in approximately the middle of wing (as in fig. 1); base of triangle in hind wing opposite arculus; spines on outer angle of hind femur of both sexes slender, gradually increasing in length distally, and not directed proximad (fig. 48); vulvar lamina at least one-fourth as long as segment 9 (often longer), rounded at apex, and projecting ventrad (figs. 70–71) ..... **Erythrodiplax**

78(76'). Ends of stigma not parallel (as in fig. 6 or 23); anal field of hind wing several cells wide, the cells not arranged in rows parallel to $A_2$ (as in fig. 18) ..... 79

78'. Ends of stigma parallel, or if not parallel, then 3–4 rows of cells in anal field of hind wing, the cells usually arranged in rows parallel to $A_2$ (as in fig. 19) ..... 80

79(78). One cell row between MA and Mspl (as in fig. 34); 1–2 cell rows between $IR_3$ and Rspl ..... **Tauriphila**

79'. Two cell rows between MA and Mspl, at least in front wing (fig. 33); 2 cell rows between $IR_3$ and Rspl (fig. 36) ..... **Paltothemis**

80(78'). Hamules 2-parted (fig. 66); vulvar lamina well developed, at least one-fourth as long as segment 9 and projecting ventrad (figs. 70–71), the apex in ventral view rounded; spines on outer angle of hind femur of both sexes slender, gradually increasing in length distally (fig. 48) ..... **Erythrodiplax**

80'. Hamules not 2-parted (fig. 62); vulvar lamina poorly developed, little more than a bilobed thickening of the caudal margin of the eighth sternite, not projecting ventrad (fig. 68); spines on outer angle of hind femur of male short and stout (figs. 45, 50) ..... 81

81(49', 80'). Tooth on tarsal claw stout and projecting (fig. 56); segments 7–9 of male widened and flattened (fig. 60); spines on outer angle of hind femur of male short, stout, and directed proximad (as in fig. 50); West Indies ..... **Scapanea**

81'. Tooth on tarsal claw smaller (fig. 57); segments 7–9 of male variable; spines on outer angle of hind femur of male not directed proximad (fig. 45); southern United States to South America ..... **Dythemis**

82(72'). Base of triangle in hind wing distad of arculus (fig. 21); wing tips usually dark; vulvar lamina and sternite of segment 9 long, extending beyond apex of abdomen (fig. 72) ..... **Uracis**

82'. Base of triangle in hind wing opposite arculus; wing tips hyaline; vulvar lamina half as long as segment 9, or less ..... 83

83(82'). Hamules 2-parted (fig. 66); vulvar lamina scoop-shaped, one-fourth as long as segment 9 or longer, and projecting ventrad (figs. 70–71), ..... **Erythrodiplax**

83'. Hamules not 2-parted (fig. 62); vulvar lamina poorly developed, little more than a bilobed thickening of the caudal margin of the eighth sternite, and not projecting ventrad (fig. 68) ..... **Dythemis**

84(63'). Posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (figs. 40–43) ..... 85

84'. Posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38, 44) ..... 88

85(84). Two cell rows between $IR_3$ and Rspl (fig. 36); Mspl well developed, subtending 2 cell rows in front wing (fig. 33) and 1 in hind wing; hind wing 43–48 mm ..... **Paltothemis**

85'. One cell row between $IR_3$ and Rspl; Mspl indistinct; hind wing 18–35 mm ..... 86

86(85'). Triangle in hind wing free, its base opposite arculus; 1–2 cubito-anal crossveins in hind wing; wing tips usually hyaline; vulvar lamina not extending beyond apex of abdomen ..... 87

86'. Triangle in hind wing free or crossed, its base distad of arculus (fig. 21); 1–6 cubito-anal crossveins in hind wing; wing tips usually dark; vulvar lamina and sternite of segment 9 long, extending beyond apex of abdomen (fig. 72) ..... **Uracis**

87(86). Two or more bridge crossveins in each wing ..... **Micrathyria**

87'. At least one wing with only 1 bridge crossvein ..... **Erythrodiplax**

88(32', 56', 84'). Aspl in hind wing straight or nearly so (fig. 20) ..... 89

88'. Aspl in hind wing bent at level of heel (as in fig. 1, 18, 19, or 22) ..... 114

89(16', 34', 62, 66', 88). Discoidal field of front wing not widened distally, usually narrowed distally (as in fig. 1); wings often yellowish, or with brownish or black markings distal to triangle ..... 90

89'. Discoidal field of front wing usually widened distally (fig. 32); wings hyaline, often with a small brownish or blackish basal spot in hind wing which does not extend beyond triangle ..... 91

90(89). Costal side of triangle in front wing three-fifths as long as proximal side, or less (fig. 12); triangle in front wing crossed; North America and West Indies ..... **Celithemis**

90'. Costal side of triangle in front wing two-thirds as long as proximal side, or more (fig. 20); triangle in front wing free or crossed; North and South America ..... **Perithemis**

91(89'). Face white; costal side of triangle in front wing more than half as long as proximal side (fig. 32); central and northern United States and Canada ..... **Leucorrhinia**

91'. Face not white; costal side of triangle in front wing usually less than half as long as proximal side; Mexico to South America ..... **Planiplax**

92(53'). One bridge crossvein ..... 93

92'. Two or more bridge crossveins ..... 111

93(92). Arculus in hind wing between first and second antenodals ..... 94

93'. Arculus in hind wing opposite or distad of second antenodal ..... 105

94(93). Tooth on tarsal claw small and near tip of claw (fig. 58), or very small, little more than a notch (fig. 59); hamules not 2-parted (fig. 63): ..... 95

94'. Tooth on tarsal claw usually normally developed (as in figs. 55–57); hamules variable ..... 96

95(24, 94). Sectors of arculus in front wing stalked (as in fig. 5) ..... **Oligoclada**

95'. Sectors of arculus in front wing not stalked (as in fig. 4) ..... **Planiplax**

96(94'). Posterior lobe of prothorax not narrowed at base, either quadrate or rounded, and usually not erect or bearing a fringe of long hairs (figs. 40–43) ..... 97

96'. Posterior lobe of prothorax narrowed at base, and usually erect and bearing a fringe of long hairs (figs. 37–38) ..... 100

97(96). Nodus in front wing distad of middle of wing (as in fig. 29) ..... 98

97'. Nodus in front wing in approximately the middle of wing (as in fig. 1) .. 99

98(61', 97). Tooth on tarsal claw usually as long as tip of claw or longer (figs. 53–54); spines on outer angle of hind femur of male short and stout and usually directed proximad (fig. 49); Mexico and West Indies to Argentina and Brazil ..... **Macrothemis**

98'. Tooth on tarsal claw much shorter than tip of claw; spination on outer angle of hind femur of male variable; Brazil to Paraguay, **Gynothemis**

99(17', 25', 60', 97'). One to two cell rows in discoidal field of front wing; hind wing 14–16 mm.; eastern United States, and Canada ..... **Nannothemis**

99'. Usually 2–4 cell rows in discoidal field of front wing, but if with only 1 then from South America; if from North America, then hind wing 17 mm. or longer ..... **Erythrodiplax**

100(96'). $IR_{2a}$ arising below proximal third of stigma, or farther proximad (as in fig. 14) ..... 101

100'. $IR_{2a}$ arising below middle third of stigma (as in fig. 13) ..... 117

101(100). One cell row between $IR_3$ and Rspl ..... 102

101'. Two cell rows between $IR_3$ and Rspl ..... 104

102(101). Costal side of triangle in front wing more than half as long as proximal side (fig. 32); face white; central and northern United States, and Canada ..... **Leucorrhinia**

102'. Costal side of triangle in front wing less than half as long as proximal side (fig. 11); face color variable; North and South America ..... 103

103(69', 102'). Spines on basal half or two-thirds of outer angle of hind femur short and of about equal length, with 3–4 large spines on distal half or third (fig. 46); hind wing 26 mm. or more, usually over 30 mm.; 3 cell rows in discoidal field of front wing ..... **Erythemis**

103'. Spines on outer angle of hind femur gradually increasing in length distally (fig. 48), or all short except the last; hind wing 29 mm. or less, usually less than 26 mm.; 2–3 cell rows in discoidal field of front wing ..... **Erythrodiplax**

104(101'). Hind wing 22–29 mm. ..... **Erythrodiplax**

104'. Hind wing 35–41 mm. ..... **Lepthemis**

105(93'). Tooth on tarsal claw usually as long as tip of claw, or longer (figs. 53–54); spines on outer angle of hind femur of male short and stout and usually directed proximad (fig. 49); nodus in front wing distad of middle of wing (fig. 29) ..... **Macrothemis**

105'. Tooth on tarsal claw shorter than tip of claw (as in figs. 55–57); spines on outer angle of hind femur of male and nodus in front wing variable....106
106(105'). Nodus in front wing distad of middle of wing (as in fig. 29)....107
106'. Nodus in front wing in approximately the middle of wing (as in fig. 1)....109
107(106). One cell row in discoidal field of front wing (as in fig. 16); costal side of triangle in front wing broken (as in fig. 16)....**Elga**
107'. Two or three cell rows in discoidal field of front wing; costal side of triangle in front wing straight....108
108(107'). Discoidal field of front wing parallel-sided or slightly narrowed distally, with 2 cell rows....**Gynothemis**
108'. Discoidal field of front wing parallel-sided or slightly widened distally, usually with 3 cell rows....**Dythemis**
109(106'). One cell row in discoidal field of front wing (as in fig. 16); tooth on tarsal claw very small, little more than a notch (as in fig. 59)....**Elga**
109'. Two cell rows in discoidal field of front wing; tooth on tarsal claw normally developed (as in figs. 55–57)....110
110(109'). One row of cells in anal field of hind wing; triangle in front wing free; inferior angle of male superior appendages located at one-third to three-fifths the length of appendage, the tips of superior appendages long and often upturned at apex....**Anatya**
110'. Two or more rows of cells in anal field of hind wing; triangle in front wing free or crossed; inferior angle of male superior appendages located at about three-fourths the length of appendage, the tips of superior appendages not long and upturned at apex..**Erythrodiplax**
111(92'). One cell row in discoidal field of front wing (as in fig. 16)....**Fylgia**
111'. Two or three cell rows in discoidal field of front wing....112
112(111'). Two or more bridge crossveins in each wing....113
112'. One or two wings with only 1 bridge crossvein....114
113(112). Sectors of arculus in front wing stalked (as in fig. 5)....**Micrathyria**
113'. Sectors of arculus in front wing not stalked (as in fig. 4)....**Planiplax**
114(35', 88', 112'). $IR_{2a}$ arising below proximal end of stigma (as in fig. 14), or farther proximad; sectors of arculus in front wing stalked (as in fig. 5); hamules 2-parted (fig. 66)....115
114'. $IR_{2a}$ variable; sectors of arculus in front wing not stalked (as in fig. 4); hamules not 2-parted (as in figs. 62–63)....116
115(114). Two bridge crossveins in each wing; 6 antenodals in front wing, the last complete; hind wing with a reddish brown basal spot which extends nearly to nodus; hind wing 19–20 mm....**Edonis**
115'. One or two wings with 1 bridge crossvein; at least 7 antenodals in front wing, the last usually incomplete; wing color and size variable, **Erythrodiplax**
116(114'). $IR_{2a}$ arising below proximal end of stigma (as in fig. 14), or farther proximad; wings hyaline, with a small basal spot in hind wing which does not extend beyond triangle; Mexico to South America, **Planiplax**
116'. $IR_{2a}$ arising below middle of stigma (as in fig. 13); wing color variable, often with yellowish or dark areas distal to triangle; United States to South America....117
117(67', 100', 116'). Abdomen slightly swollen at base, segments 3–10 stout and tapering caudad; wings hyaline with a small basal spot, **Brachymesia**
117'. Abdomen distinctly swollen at base, segments 3–10 more slender with lateral margins parallel; wings often with postnodal yellowish or dark coloration....**Cannacria**

### THE SUBGENERA OF LIBELLULA

On the basis of penis structure, Kennedy (1922) has divided the genus *Libellula* into ten subgenera, of which seven occur in the New World. These seven subgenera are *Belonia* Kirby (type=*foliata*

Kirby), *Eolibellula* Kennedy (type = *semifasciata* Burmeister), *Holotania* Kirby (type = *axillena* Westwood), *Ladona* Needham (type = *exusta* Say), *Libellula* Linnaeus *s. str.* (type = *quadrimaculata* Linnaeus[36]), *Neotetrum* Kennedy (type = *forensis* Hagen), and *Plathemis* Hagen (type = *lydia* Drury).

A key to the seven New World subgenera of *Libellula* is given below. This key is based chiefly on wing characters rather than penis characters in order that it may be used for material of either sex. Since there is relatively little uniformity in wing characters within a subgenus, some of the subgenera containing more than one species key out at two or more places in the key.

KEY TO THE NEW WORLD SUBGENERA OF THE GENUS LIBELLULA

1. Stigma bicolored (*comanche* Calvert, *cyanea* Fabricius, *flavida* Rambur), **Holotania**
1'. Stigma uniformly colored ..... 2
2(1'). $IR_{2a}$ usually arising under proximal fourth of stigma (fig. 14); wings with basal spot only; hind wing 35 mm. or less (*deplanata* Rambur, *exusta* Say, *julia* Uhler) ..... **Ladona**
2'. $IR_{2a}$ arising under middle third of stigma or beyond (fig. 13); wing color variable, but if wings have only a basal spot then hind wing is more than 35 mm. in length ..... 3
3(2'). Male with a pair of prominent ventral hooks on segment 1 (fig. 61); female with blackish basal, nodal, and usually also apical wing spots, the basal spot not covering triangle; hind wing 35 mm. or less (*lydia* Drury, *subornata* Hagen) ..... **Plathemis**
3'. Male without a pair of prominent ventral hooks on segment 1; wing color of female variable, but if colored as above then either the spots are brownish instead of blackish, or the basal spot in front wing covers part of triangle, or the hind wing is over 36 mm. in length .... 4
4(3'). Basal one-third to two-thirds of wings reddish or brownish black, the remainder (except possibly tips) without dark spots or bands ..... 5
4'. Wings not so marked ..... 8
5(4). Base of wings brownish black, bordered distally in male with chalky (*luctuosa* Burmeister) ..... **Holotania**
5'. Base of wings reddish; no chalky areas in wings ..... 6
6(5'). Two cubito-anal crossveins in hind wing; reddish color of wing base not extending beyond nodus ..... 7
6'. Usually only 1 cubito-anal crossvein in hind wing; reddish color of wing base usually extending beyond nodus, at least in costal area (*saturata* Uhler) ..... **Belonia**
7(6). Two cell rows between MA and Mspl in hind wing; outer branch of ventral face of hamule trapezoidal, and the distance from anterior to posterior margin almost as great as from mesal to lateral margin, the margins elevated to form a ridge; inner branch of hamules short (*gaigei* Gloyd) ..... **Holotania**
7'. Usually only 1 cell row between MA and Mspl in hind wing; outer branch of hamule with distance from anterior to posterior margin of ventral face less than half the distance from mesal to lateral margin, the margins not elevated to form a ridge; inner branch of hamule long (*croceipennis* Selys) ..... **Belonia**
8(4'). Nodal spots present ..... 9
8'. No nodal spots present ..... 15
9(8). Nodal spots extending over half or more of wing width ..... 10
9'. Nodal spots covering only one or a few cells near nodus ..... 11
10(9). Wing spots yellowish to reddish brown; no chalky areas on wings (*semifasciata* Burmeister) ..... **Eolibellula**

[36]See footnote 3, page 170.

10'. Wing spots brownish black; at least males with chalky areas on wings (*pulchella* Drury, *forensis* Hagen) ..... **Neotetrum**

11(9'). Costal area of wings tinged with yellow ..... 12

11'. Costal area of wings not tinged with yellow ..... 13

12(11). Basal spot in hind wing triangular, veins in spot lighter than spot (*quadrimaculata* Linnaeus) ..... **Libellula**

12'. Basal spot in hind wing usually not triangular, if triangular then veins in spot are darker than spot (*composita* Hagen, *flavida* Rambur), **Holotania**

13(11'). Either with costa whitish (*composita* Hagen, western United States), or basal spot in hind wing not extending beyond first antenodal (*incesta* Hagen, eastern United States) ..... **Holotania**

13'. Costa dark; basal spot in hind wing extending to arculus and second or third antenodal ..... 14

14(13'). Basal spot in hind wing extending at least from Sc to CuP or A; western North America (*nodosticta* Hagen) ..... **Noetetrum**

14'. Basal spot in hind wing usually confined to subcostal space; eastern North America (*axillena* Westwood, *vibrans* Fabricius) ..... **Holotania**

15(8'). Abdomen and thorax robust; costa dark; Mexico to Paraguay (*foliata* Kirby, *herculea* Karsch) ..... **Belonia**

15'. Abdomen and thorax relatively slender; costa variable; United States, gulf coast of Mexico, and Cuba (*auripennis* Burmeister, *composita* Hagen, *flavida* Rambur, *incesta* Hagen, *needhami* Westfall) .. **Holotania**

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# IMMATURE FORMS OF THE MITE, CAECULUS PETTITI

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Vitzthum (1933) described the larva of a new species of mite, *Caeculus willmanni*, from Guatemala. Both the description and the figure of this larva are so at variance with the appearance of *C. pettiti* that it was thought worth while to describe and to figure the larva and nymph of the latter species. Jacot (1936) compared some nymphal characters with adult characters for *C. laoshanensis*, *C. sinensis* and *C. sinensis taishanicus*.

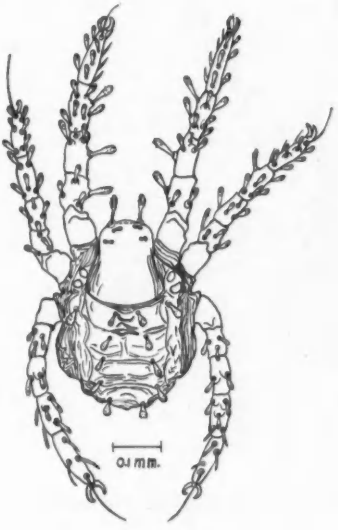


FIGURE 1.
Dorsal view of the larva of *Caeculus pettiti*.

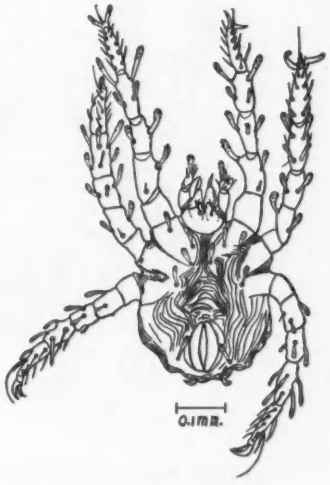


FIGURE 2.
Ventral view of the larva of *Caeculus pettiti*.

The general appearance of the immature stages of *Caeculus pettiti* is so similar to that of the adult that there can not be any question of the identity without rearing specimens.

*The Larva* (figs. 1 and 2).—The larva is distinguished from the other forms by its smaller size, by the presence of three pairs of legs each with five segments, by the presence of a small number of setae and by the absence of genital plates. There is no area differentiated to indicate where the genital plate will appear in the nymph.

Vitzthum (1933) figured the larva of *C. willmanni* with six-jointed legs. The number of legs, the size of the specimens and the number of setae present indicate that he was dealing with the larval form. The presence of six segments in the legs of *C. willmanni* and of five segments in the legs of *C. pettiti* may be a specific difference between the two species. In *C. pettiti* ridges on the basal segment might readily be mistaken for true segmentation.

Two main features of the dorsal surface of the larva which differentiate it from the nymphs and adults are the proportionally larger

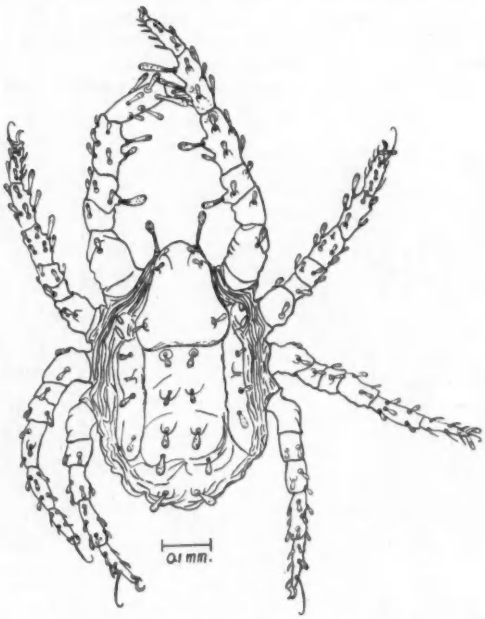


FIGURE 3. Dorsal view of the first stage nymph of *Caeculus pettiti*.

capitulum of the former and the quite definite appearance of segmentation of the notogaster of the larva. The number of and the arrangement of the setae also differ. There are two pairs of anterior and antero-lateral setae on the capitulum. The postero-lateral setae of the capitulum are lacking. On the notogaster there are five pairs of setae arranged in what appears to be one pair per segment. There is one pair of setae on the dorso-lateral plates. These plates are hyaline in appearance as are the other parts of the body. Sclerotization has not occurred.

On the ventral surface of the larva it will be noted that anal setae are lacking, although one pair of lateral anals is present. There are

three setae on each of the coxal plates of leg I, and one seta at the base of each coxal plate III.

Length of larvae, 0.26–0.36 mm.; average for 13 specimens, 0.3 mm.

*The Nymph* (figs. 3 and 4). The first stage nymph bears four pairs of legs. The first three pairs are always made up of six joints, the fourth pair usually of only five joints. In one case a small indistinct third joint was present making a total of six for the fourth leg. A comparison of the arrangement of the setae as represented in the drawings of the dorsal surfaces of the larvae and of the nymph, figures

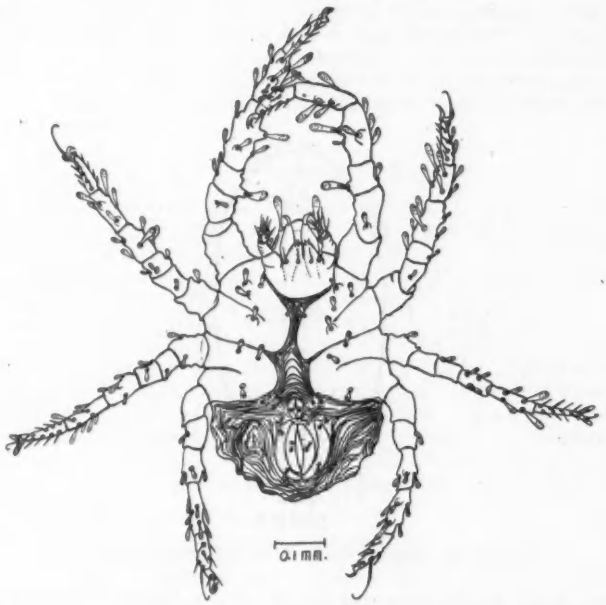


FIGURE 4. Ventral view of the first stage nymph of *Caeculus pettiti*.

1 and 3, will show that it is the second or the next to the basal segment which has divided to produce the sixth segment.

In dorsal view the first stage nymph appears intermediate between the larvae and the adult. One pair of postero-lateral setae is present on the capitulum. Each dorso-lateral plate on the notogaster bears three setae. A slight indication of segmentation of the notogaster still shows.

On the ventral surface the genital plate bearing one pair of setae is present. The anal plates bear one pair of setae, the lateral anals two pairs. The number of setae on the coxal plates has been increased to 4, 1, 2 and 1 on legs I to IV respectively. Two pairs of setae are present in the wrinkled cuticula between the genital plates and the

coxal plates IV. The ventral surface of the capitulum is much the same as in the adult.

Length 0.35–0.58 mm.; average for 10 specimens, 0.45 mm.

*The Second Nymphal Stage.*—Only one specimen of what I believe to be the second nymphal stage was found. It might be that this specimen represents the opposite sex from the adult specimens described in an earlier paper (Nevin, 1943). The possibility that this specimen represents the adult of a distinct species is unlikely but is not entirely ruled out. No other forms were obtained from succeeding collections from the same area. The second stage nymph bears three pairs of setae on the genital plate (figure 5), in contrast to seven pairs present in the adult. The fourth pair of legs is now made up of six segments. The numbers of and the locations of the other setae which can be seen in this specimen are much the same as in the adult mite.

Length of specimen of second nymphal stage, 0.8 mm.

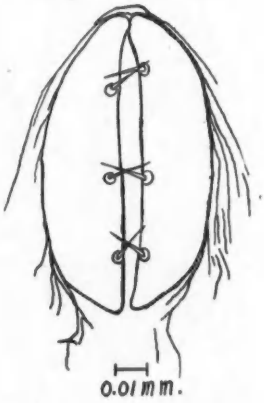


FIGURE 5. Genital plates of second stage nymph.

The above descriptions are based upon a study of specimens of larvae and nymphs collected from pine needles sent to me from Elk Creek, Grayson County, Virginia, by Dr. Lincoln C. Pettit of Washington and Lee University.

The outlines of all drawings were made with the aid of the camera lucida.

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# A NEW GENUS ACUNASUS AND EIGHT NEW SPECIES OF MEXICAN LEAFHOPPERS

## (Homoptera: Cicadellidae)

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Collecting in Mexico has brought to light several closely related species for which the Genus *Acunasus* has been erected. Apparently none of these species have been described and all seem to occur at elevations of from 2000 to 3000 feet. Most of these have been collected in the state of Guerrero, but one specimen was taken in the state of San Luis Potosi. They all live apparently upon the larger types of annuals or the shrub type of perennial in the hot dry areas of the low mountain ranges.

### Genus **Acunasus** nov.

Probably related to *Mesamia* and *Twiningia*. The vertex is rather broad and not strongly produced and rather broadly rounded. The margin is thin, almost foliaceous, sloping upward. The disc between eyes is depressed and excavated. Face only slightly convexly rounded, extending straight to vertex margin. Pronotum decidedly wider than vertex with strongly produced lateral angles. Elytra with two cross veins on inner sector. The second anteapical cell is long and slender, decidedly longer than first and third anteapical cells. The first anteapical is usually divided. Several costal veinlets are present especially on apical half. Clavus with very few cross veins. The male aedeagus is a complicated structure with a coiled basal portion in every species and is difficult to describe. Genotype *Acunasus nigriviridis* n. sp.

All type specimens, unless otherwise designated, are in the author's private collection.

### **Acunasus nigriviridis** n. sp.

A greenish species marked with black on vertex and with brown to blackish elytra. Length 6–6.5 mm.

Vertex rather broad and short, almost twice as wide between eyes at base as median length and only slightly longer at middle than next the eyes. The disc is deeply excavated so as to form a sharp edged margin which is narrowly foliaceous with the front. Face slightly indented either side of middle below the margin of vertex.

*Color.*—Green tinged with yellow, with four black spots just above margin. The pair at middle are proximal and larger than the spot next each ocellus. Scutellum green with yellowish basal angles. Face green washed with yellow, the black spots on margin of vertex visible from below. Elytra yellowish hyaline, veins darker, the claval area dark brown with white areolar spots, the brownish coloration often extends onto the corium.

*Genitalia.*—Male valve short, transverse, lying in the concavity of the last ventral segment. Male plates long, gradually tapered to

bluntly pointed apices. Aedeagus complicated in structure, composed of an S-shaped twisted tubular portion which passes through a straighter portion at about its middle. The pygofer bears a long black spine on each side arising on the inner ventral margin at about its middle and extends for about one-third the length of the pygofer beyond its apex.

***Holotype male and paratype males*** from Iguala, Gro., Mexico, October 25, 1941, (Good and DeLong), and September 11, 1939, (Plummer and DeLong). ***Paratype males*** from Cocula, Gro., Mexico, August 6, 1930 (M. F. 1733) Dampf.

**Acunasus cruciatus** n. sp.

In form and general appearance resembling ***nigriviridis*** but with different color pattern and distinct genitalia. Length 6 mm.

Vertex more than one-half as long at middle as basal width between the eyes, depressed just back of apex.

*Color*.—Vertex dull green, the anterior marginal border paler with a pair of apical spots which are triangular and scarcely separated and a smaller spot next each ocellus. Pronotum dull green, disc and posterior portion brownish. Scutellum dull green tinged with brown, the basal angles brown. Elytra pale with a wide brownish border along the margin of scutellum, an angular brown saddle across middle of clavus, the narrow pointed ends of saddle terminate on middle of costa on either side. Tip of clavus, second anteapical cell and apices of elytra, brown. Face bright green, with black spots of margin showing from below.

*Genitalia*.—Male plates elongate, triangular with narrow blunt apices. Style with a long, narrow, finger-like apical portion which is almost as long as basal portion. Aedeagus consisting of a coiled tube at base, which is narrow but becomes widened to form a blunt caudal portion and a blunt dorsal finger-like portion separated from the caudal portion by a deep U-shaped excavation. The pygofer bears a rather short, heavy spine which arises on the ventral caudal angle, extends dorsally and is fused for more than half its length with the caudal margin of pygofer.

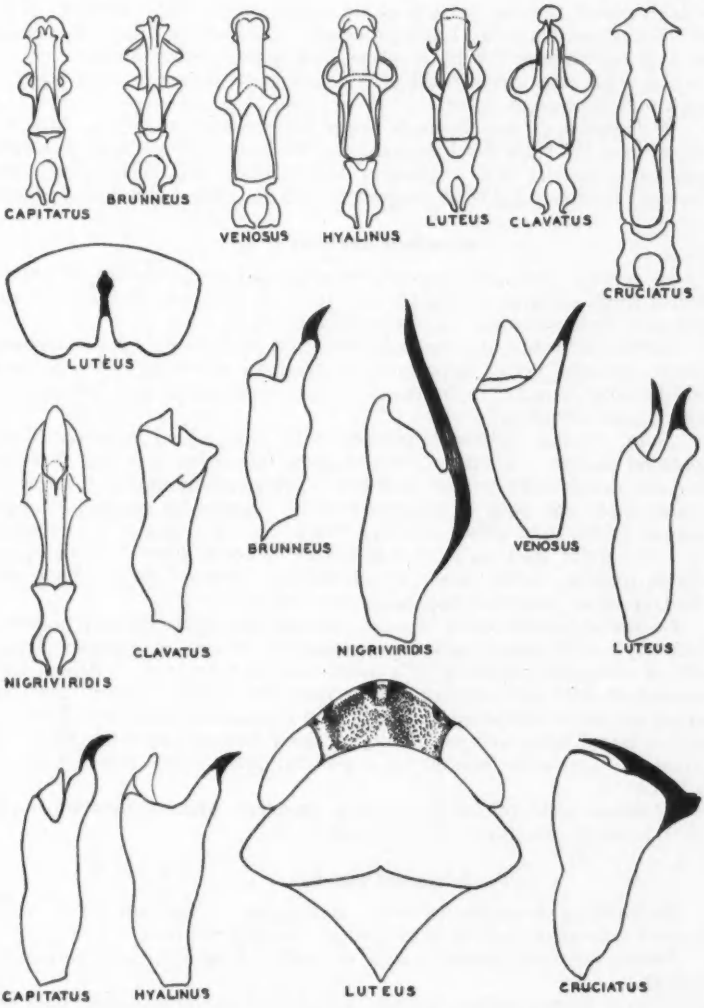
***Holotype male*** collected at Iguala, Gro., Mexico, September 11, 1939, by Plummer and DeLong.

**Acunasus brunneus** n. sp.

A brown species resembling ***nigriviridis*** in general form and with distinct genitalia. Length 5.5 mm.

Vertex not quite twice as wide between eyes at base as median length.

*Color*.—Vertex brown with four black spots on anterior margin. A pair of proximal angular spots at apex and a smaller square spot next each ocellus. A white spot at either side of middle next margin of eye. Pronotum dark brown, anterior margin paler brown, a transverse row of white spots just back of margin. Scutellum brown, a white spot at about half the distance on each side. Elytra hyaline, marked with brownish irrorations on clavus, disc, and apex so as to form a saddle across middle of elytra and a darkened area at apex. Face dull yellow irrorate with brown.




Dorsal view of head, last ventral female segment, ventral view of aedeagus and ventral view of pygofer of *Acunasus luteus* n. sp. Ventral view of aedeagi and pygofers of other species as labeled.

*Genitalia.*—Male plates triangular, elongate, with blunt apices, only slightly exceeding in length the narrow elongated styles. Aedeagus with a coiled tubular portion at base, the apical half enlarged. The dorsal surface bears two blunt processes separated by a deep U-shaped excavation. Pygofer with a rather long spine arising on the ventro-caudal angle, the apical third of which is bent, narrowed to a pointed apex and is black in color.

*Holotype male and paratype males* taken at Iguala, Gro., Mexico, September 11, 1939, by Plummer and DeLong. Three *male paratype* specimens in the Ball collection U.S.N.M., were collected on the Cuernavaca-Acapulca road, August 22 and 23, 1939, by Ball and Stone.

**Acunasus hyalinus** n. sp.

In general form and appearance resembling *nigriviridis*, but with vertex more abruptly produced next the eyes and with distinct coloration and male genitalia. Length, male 6.5 mm.

Vertex about one and one-half times as wide between eyes as median length, and the vertex appears to be abruptly produced next the eyes and broadly rounded in front. The disc is depressed and the margin is thin and turned up.

*Color.*—Vertex yellowish marked with orange and with six black spots on margin. There are two at apex, one either side just anterior to each ocellus and one next each eye. Pronotum orange with a row of yellow spots just back of anterior margin. Scutellum orange, a longitudinal yellow spot either side just inside the basal angles terminating in a triangular spot on each side about half-way from base to apex. Elytra hyaline, veins orange, costal veinlets brown. Face yellow, the black spots on margin conspicuous from beneath.

*Genitalia.*—Male plates elongate, triangular; apices bluntly pointed, each style with apical half forming narrow, finger-like apices. Basal half of aedeagus consisting of a coiled tube-like structure. Apical half broadened with an anterior and a posterior dorsal process, both of which are blunt and separated by a deep U-shaped excavation. Pygofer with a broad spine-like projection on the ventro-caudal angle which is broad at base and tapered to a pointed apex. The apical portion is black.

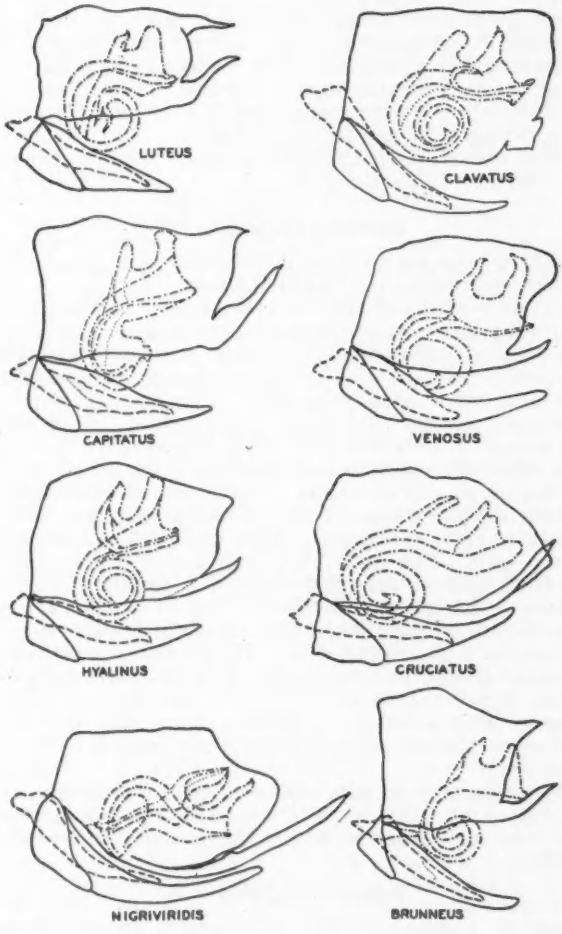
*Holotype male* collected at Iguala, Guerrero, Mexico, September 11, 1939, by C. C. Plummer and the author.

**Acunasus venosus** n. sp.

Resembling *brunneus* in form and general appearance but with distinct coloration and male genitalia. Length 5.5 mm.

Vertex not quite twice as wide as median length, broadly, obtusely angled.

*Color.*—Vertex yellow irrorate with brown, a round white spot on either side next margin of eye. Margin with a pair of triangular spots at apex. An elongate spot just anterior to each ocellus and a black spot just above ocellus next each eye. Pronotum dull brown with a row of pale spots just back of anterior margin. Scutellum pale orange with a longitudinal line just inside basal angles extending to middle of




Lateral views of male last abdominal segments as labeled showing aedeagi and styles in lateral view.

margin on either side. Elytra white, the veins orange and appearing raised or embossed. Face pale yellow, the black spots on the margin showing from beneath.

*Genitalia.*—Male plates elongate, triangular, apices bluntly pointed. Style with apical third slender, finger-like. Aedeagus coiled at base, apical portion broad with the caudal ventral angle pointed and with two rather long dorsal processes which are formed by a deep U-shaped excavation which separates these processes. Pygofer with a rather long spine on ventro-caudal margin which is broad at its fusion with pygofer and tapers to a narrow, pointed apex.

***Holotype male*** collected at Iguala, Guerrero, Mexico, September 11, 1939, by Plummer and DeLong.

**Acunasus clavatus** n. sp.

Resembling ***hyalinus*** in general form but with unique coloration and distinct male genitalia. Length 5.5 mm.

Vertex more produced than in other species of the genus, about one-third wider between eyes at base than median length .

*Color.*—Vertex dark orange; margin, a median longitudinal stripe and a narrow stripe next each eye, pale. Margin marked with a pair of black semicircular spots at middle. A spot just anterior to each ocellus and another next either eye. Pronotum orange to brown with a row of elongated spots just back of anterior margin. Scutellum dull orange, a small white spot in each basal angle and an elongated white spot on disc either side of middle. Elytra with clavus orange brown, with white, parallel elongated oblique markings along veins. Disc and costal area pale, veins orange brown, discal cell and anteapical cells with brown spots. Face pale yellow with darker yellow markings and with the black spots on margin showing from beneath.

*Genitalia.*—Male plates triangular with blunt rounded apices. Style with apical-third slender, finger-like. Aedeagus with ventral basal portion composed of a coiled tube. The dorso-apical portion with a pair of dorsal structures separated by a broad rather deep U-shaped excavation. Apex tapered and narrowed to an obliquely sloping blunt tip. Pygofer with a broad triangular ventral plate on the ventro-caudal margin which is separated from the pygofer by a notch on caudal margin.

***Holotype male and paratype male*** collected at Zirandaro, Guerrero, Mexico, August 29, 1930, by Dr. Dampf. (M. F. 1786); ***paratype male*** from San Geronimo, Guerrero, Mexico, August 30, 1930, by Dr. Dampf. (M. F. 1787).

**Acunasus capitatus** n. sp.

Resembling ***brunneus*** in form and general appearance but with distinct male genitalia. Length 5 mm.

Vertex rather broadly rounded, appearing almost parallel margined, a little more than half as long at middle as basal width between the eyes.

*Color.*—Pale brown, a pair of black spots at apex of margin separated by a white V-shaped spot. A black spot on margin just anterior to each ocellus and a white spot just back of each ocellus and next either

eye. Pronotum pale brown on anterior margin with a row of eight white spots. Disc and posterior portion of pronotum dark brown. Scutellum pale brown with a pale spot on anterior margin either side of median third and a larger white spot at the middle on each lateral margin. Elytra subhyaline with pale brown veins. Brownish irrorations on base, disc, central anteapical cell and apices of apical cells of elytra. Claval portion washed or irrorate with brown in certain areas. Face yellow irrorate with brown.

*Genitalia.*—Male plates rather short, triangular, apices blunt but narrow and rounded. Apical half of style narrow, finger-like. Basal half of aedeagus composed of a flat plate-like structure with a tube coiled about its margin. This plate is constricted just before the basal half which is blunt at apex, produced a little more on ventral margin. Dorsally there is a pair of finger-like processes separated by a rather deep U-shaped excavation. Pygofer with a large spine produced on the ventro-caudal angle. The basal half is broad with the sides convexly rounded, the apical half is narrow and forming a curved pointed spine.

***Holotype male*** collected at Tequila, Jalisco, Mexico, August 24, 1937, ***paratype males*** from Iguala, Guerrero, Mexico, September 11, 1939. (Plummer and DeLong.)

**Acunasus luteus** n. sp.

In form and general appearance resembling ***brunneus*** but with distinct male genitalia. Length 5.5 mm.

Vertex rather broadly rounded, only slightly longer at middle than next the eyes and more than half as long at middle as basal width between the eyes.

*Color.*—Vertex with anterior margin white, disc and posterior margin orange brown. A pair of black, slightly separated angular spots at apex and a smaller black spot just anterior to each ocellus. A small black spot is just posterior to each ocellus posterior to which is a white spot next each eye. Pronotum pale brown on anterior margin with a row of eight white spots just posterior to anterior margin. Disc and posterior portion dark brown. Scutellum white with round orange spots on basal angles and the median third mottled with coalescing brownish spots. Elytra whitish subhyaline with brownish veins and brownish areas on clavus. Scattered brown irrorations on the elytra. Face pale yellow with pale brown irrorations.

*Genitalia.*—Female last ventral segment rather long lateral margins rounded to posterior margin which is deeply notched at middle either side of which the posterior margin is concavely rounded to the slightly produced rounded tip on outer portion of margin. Male plates rather short, triangular and with the apices bluntly angled. Style with the apical half forming slender finger-like processes. The basal half of aedeagus joining a coiled tube. The apical half broad, with a pair of short, thick dorsal processes separated by a short, narrow U-shaped notch. The posterior process is much larger than the anterior process. Pygofer with a long narrow pointed spine on the dorsal caudal angle and a broader spine on the ventro-caudal angle. The basal half is

broad and convexly rounded on the inner margin forming a rounded protrusion beyond which the apical half is rapidly narrowed to form a tapered curved pointed black spine.

***Holotype male and paratype males*** collected at Iguala, Guerrero, Mexico, September 11, 1939 (Plummer and DeLong) and October 25, 1941, (Good and DeLong). One male paratype was collected at Balsas, Guerrero, Mexico, August 15, 1930, by J. Parra. (M. F. 1754). ***Allotype female and paratypes males and females*** in the Ball collection U.S.N.M. were collected on the Cuernavaca-Acapulca road, August 20 and 23, 1936, by Ball and Stone and at Jalaca, S.L.P., Mexico, August 13, 1936, by Ball.

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TYROGLYPHID MITES IN STORED PRODUCTS. I. A SURVEY OF PUBLISHED INFORMATION. SUPPLEMENT, 1944, by M. E. SOLOMON. Department of Scientific and Industrial Research, Pest Infestation Laboratory. Published by His Majesty's Stationery Office, York House, Kingsway, London W. C. 2. Price, 5 cents.

This seven-page bulletin is a concise summary of information supplementary to the older Survey. It covers morphology and internal anatomy, biology, bio-ecology, physical ecology, tyroglyphids in stored products and their control, and includes a bibliography of 39 titles. The facts mentioned include some of general biological interest, such as the occurrence of tracheae in *Gohieria fusca* (Ouds.) and the amazing fecundity of *Chortoglyphus gracilipes* Banks, of which one female may give rise to 8,000,000 mites within a month. Data on control include some evidently important advances.—A. W. L.

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THE NATURE AND PROPERTIES OF SOILS, by T. LYTTLETON LYON and HARRY O. BUCKMAN. Pp. xix 499, 58 figs. Macmillen Co., 1943. Price, $3.50.

Insects, along with myriads of other invertebrate organisms, play no small part in determining the "Nature and Properties of Soils." "A great variety of insects are found in soils, some of which have very little influence on the organic matter, while others, such as ants, beetles, springtails, . . . appreciably affect the humic constituents, either by translocation or by digestion."

Soil conservationists in their efforts to devise rotations, cropping systems and tillage methods to prevent soil losses by wind and water erosion have been confronted with serious insect problems. High grasshopper populations incidental to stubble mulch and surface trash cultivation, increased chinch bug damage in strip cropping systems, increased wire worm and white grub damage accompanying lengthened rotations and high infestations of mirids in orchards under sod culture are only a few of the many instances where insect control and soil management measures are at odds.

These differences can be reconciled only through an understanding both of insect and soil problems. This book is admirably suited to equip the entomologist who has not had instruction in the latter subject with a basic understanding of the nature and property of soils and their management. In this, the fourth edition of the book, much new information has been incorporated which is of interest to economic entomologists. Two chapters on the origin, nature, formation and classification of soils should be of particular interest to insect ecologists and taxonomists interested in distribution problems.

Although intended primarily as a college text of edaphology the style of the book is well adapted to use for self instruction and for reference.

—CHARLES A. DAMBACH.

# NOTES ON AND DESCRIPTIONS OF MEXICAN ORTHOPTERA

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## Family **Gryllacrididae**

### **Stenopelmatus sartorianus** Saussure

In 1932 Hebard (p. 343) considered three names, *sallei*, *sumichrasti* and *sartorianus*, used in the genus *Stenopelmatus* by Saussure in 1859, and synonymized *sartorianus* under *sumichrasti*. At the same time Hebard questioned the validity of *sumichrasti* since *sallei* has line priority and the specimen upon which Saussure based the name *sumichrasti*, and which he supposed to be an adult, actually is an immature individual. Hebard expressed himself as uncertain as to the described differences in the facial scutella of *sallei* and *sumichrasti* but apparently had only Costa Rican material at hand whereas the types of all three are from "Mexico" and most likely from the state of Vera Cruz. From evidence from three adult females, two large immature females with wing pads and two small immatures collected at Cordoba, V. C., by Dr. C. H. Seevers it appears certain that the three names apply to one species. Although Saussure in his original description and later (1893?) key described the facial scutellum of *sallei* as broad, the figure (1893, pl. 14, fig. 11) agrees closely with the specimens before me. Actually the frontal carinae do not meet above, but there the interval between them is half, or less than half as broad as the interval below. In one of the large immatures before me there is a light line on each frontal carina; these lines meet above and continue as a single median line over the vertex and occiput but the carinae are separate above. In all the larger specimens there is, just below the point of closest approach to the carinae, a very shallow, semicircular depression. This is well shown in Saussure's figure. The form of the clypeus is distinctive and apparently primitive, and is shown in the figure cited. All the specimens at hand are similar in this respect except one adult in which the clypeus is grossly malformed and the labrum absent. Perhaps the name *sallei* should be retained on line priority but it seems to me the better course to use *sartorianus*, the name applied to the adult and easily recognized form.

### **Argyrtes maculatus** new species

This, the third species of the genus to be described, is a nondescript insect offering no immediately perceptible diagnostic features. I am not certain that the male allotype is mature but its size is very little less than that of the female type, which is certainly mature.

*Type.*—Female, Tancitaro, Michoacan, VII-20-40 (Hoogstraal and Knight). Author's collection. Fastigium of vertex shorter than in *macropus* (from description) and without groove. Front femur (right)

armed on ventrocephalic carina with a small pregenicular spur; the left femur without such a spur; ventrocaudal carina unarmed. Front tibia with a pair of small upper and larger lower apical spurs; each ventral carina armed with five spurs, of which the third is somewhat larger than the others, which are subequal. Front coxa with a prominent lateral spine. Middle coxa unarmed. Middle femur with a small preapical spur on ventrocephalic carina and a stout, short genicular spur on caudal face. Middle tibia with a small spur on dorsocephalic carina about two-fifths the length of tibia from base, and another at distal three-fifths. Dorsocaudal carina with a single small spur at proximal fourth. Each ventral carina with five spurs. Apical spurs similar to those of front tibia. Posterior femur with a few, minute, widely spaced denticles on ventrocephalic carina and similarly spaced, larger spines on ventrocaudal carina. Hind tibia with five spurs on each dorsal carina; between the spurs and proximal to them the carinae are denticulate. Ventral surface of hind tibia with several small spurs, including a subapical pair. Dorsocaudal calcar not quite reaching dorsal apex of metatarsus. Dorsocephalic calcar about four-fifths as long as dorsocaudal one. Metatarsus about equal in length to the following three joints combined. Ovipositor with apical tooth of ventral valve evenly and markedly decurved; the subapical tooth is directed slightly caudad; the proximal three teeth are directed straight downward. Subgenital plate entire, evenly rounded. Suranale heart-shaped.

Coloration: Dark brown on dorsum and legs, much mottled with yellow; there is no definite color pattern. In general appearance this insect recalls *Ceuthophilus brevipes* Scudder. Under surface and margins of thoracic epipleurae pale. Measurements (mm.): body, excluding ovipositor, 14; pronotum, 4.2; front femur, 6.1; hind femur 11.5; ovipositor, 6.5.

*Allotype.*—Male, data as for type. Fastigium, coxae, front femur and tibia, and coloration as in type. Middle femur with caudal genicular spine and two, small, closely spaced, preapical spurs on each ventral carina. The middle tibia, in addition to the two pairs of apical spurs, is armed with five spurs on each ventral carina and two spurs on each dorsal carina; these last are not arranged as pairs. Hind femur with four short spines on distal two-thirds of ventrocephalic carina; between these spines are small, lateral denticles. Ventrocaudal carina with nine short spines. There is a minute genicular spine. Posterior tibia as in female. Subgenital plate feebly chitinized, not produced, arcuately excised at end and with a short, blunt, unjointed style at each apical angle. Cerci simple, unjointed, conical. The penis is extruded as a long, whip-like structure. Measurements (mm.): body, 13; pronotum, 3.3; front femur, 5; hind femur, 10.7.

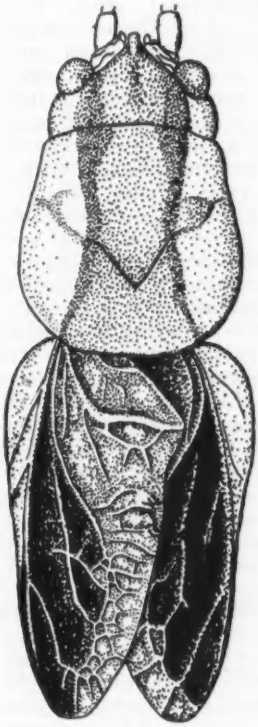
I also refer to this species two males and one female (paratypes) and three immature females, all bearing the same data as the type.

From *macropus* (Rehn), known only from the female, the present species may be distinguished by its shorter dorsocaudal calcar; from *mexicana*, S. & P., known only from the male, by the heavily armed hind femur of that species.

**Pristoceuthophilus pedanus** new species

Mr. Hebard has helped by examining the proposed type and giving me an authoritative opinion.

*Type.*—Male, Tancitaro, Michoacan, VII-20-40 (Hoogstraal and Knight). Author's collection. Characters of *Pristoceuthophilus* as given by Rehn (1902, p. 17) and Hubbell (1936, p. 31), fastigium



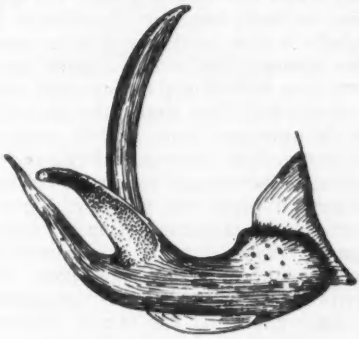


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FIG. 1. *Dichopetala cultricerca* new sp., head, pronotum and tegmina of type.
FIG. 2. *Dichopetala cultricerca* new sp., cercus of type, lateral aspect.
FIG. 3. *Dichopetala cultricerca* new sp., cercus of type, dorsocaudal aspect.

produced, blunt-conical, tarsal claws with basal seta, subgenital plate with styles. Fastigium extending well in front of antennal sockets, acutely rounded at apex. Eyes truncate anteriorly, rather evenly rounded behind, about as deep as infraocular portion of gena. Coxae unarmed, the front one obtusely angulate externally. Front femur

entirely unarmed; middle femur unarmed except for a stout genicular spine on caudal face; hind femur massive and heavily sclerotized, armed on ventrocephalic carina with five teeth, the first and smallest before the middle, the last and largest a little before the apex. Ventrocaudal carina unarmed. Front tibia with a pair of small dorsal and larger ventral spurs at apex and three pairs of spurs on ventral surface arranged from about the middle to near the apex. Middle tibia similar in armament to front one but in addition it has two small spurs on dorsocephalic carina and one similar spur on dorsocaudal carina. Hind tibia strongly but evenly curved on its basal third, thence straight, serrate on both dorsal carinae and nodulose below. Each dorsal carina is armed with five spurs, the opposite spurs arranged as pairs except for the proximal ones. Hind metatarsus as long as succeeding three joints together; dorsocaudal calcar reaching to apical fourth of metatarsus; dorsocephalic calcar about two-thirds as long as dorsocaudal. Subgenital plate not produced, arcuately emarginate behind with a short, blunt, unjointed style at each apical angle. Tenth abdominal segment visible dorsally as a pair of broad, triangular processes; paraprocts membranous for most part, bulbous. Cerci simple, distal two-thirds divided into eleven segments. Pseudosternite as illustrated. The specimen and the others reported below came to me in alcohol. The description of the tenth tergite, paraprocts and subgenital plate is based on the condition of the specimen after hardening in absolute alcohol and xylol. Relaxation of the insect for extraction of the pseudosternite and subsequent drying have resulted in much shriveling of the first two parts and some distortion of the subgenital plate. In color the type is very dark brown with a broad, sharply contrasting, pale, dorsal stripe, a row of pale spots across the posterior margin of each thoracic segment. Legs and under surface dark. Tergites 2–6 bear on either side a group of blunt-conical protuberances. The form and arrangement of these may be of taxonomic value but on each segment those of opposite sides are highly asymmetric. Measurements (mm.): body, 9.6; pronotum, 2.8; front femur, 3.6; hind femur, 8.7; hind tibia, 9.8.

*Allotype.*—Female, all data as for type. Generally similar to type but with dark coloration not so intensive, the color pattern therefore less contrasting. Fastigium and first two pairs of legs as in male type. Hind femur unarmed, more slender than in male. Hind tibia straight, armed as in male (the right tibia lacks the distal pair of spurs). Tarsus and calcars as in male. Measurements (mm.): body, 9.1; pronotum, 2.5; front femur, 3.2; hind femur, 7.3; hind tibia, 7.8; ovipositor, 4.5.

A paratypic female is somewhat larger than the allotype but otherwise very similar to it. Data identical with those for type.

## Family **Tettigoniidae**

### **Dichopetala poecila** Hebard

Dr. C. H. Seevers collected a series of five males and five females of this species at Valles, San Luis Potosi. Hitherto the male type has been the only specimen known. The female of *poecila* is very much like the same sex of *castanea* R. & H., but more intensively colored, the

orange areas especially brilliant. It is also somewhat larger with the ovipositor longer and proportionately more slender. Measurements (mm.): pronotum, 5; front femur, 10; hind femur, 24; hind tibia, 28.7; ovipositor, 9.4.

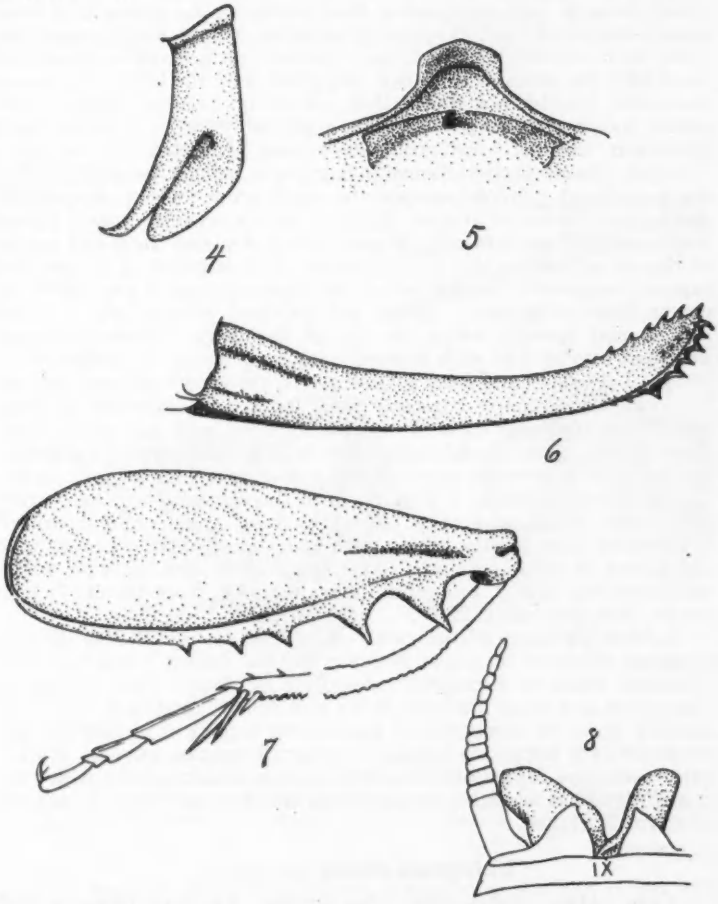



FIG. 4. *Dichopetala chirura* new sp., right cercus of type, dorsal view.
FIG. 5. *Pristoceuthophilus pedanus* new sp., pseudosternite of type.
FIG. 6. *Dichopetala chirura* new sp., ovipositor of allotype.
FIG. 7. *Pristoceuthophilus pedanus* new sp., hind leg of type (part of tibia omitted).
FIG. 8. *Pristoceuthophilus pedanus* new sp., apex of abdomen, dorsal view.

It is almost certain that the Tamos, Vera Cruz specimen reported as *castanea* by Rehn and Hebard in 1914 (p. 99) actually represents *poecila*.

**Dichopetala cultricerca** new species

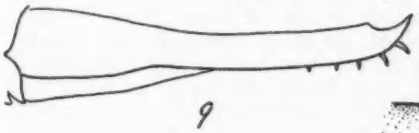
*Type.*—Male, Villa Santiago, Nuevo Leon, VI-19-40 (Hoogstraal and Knight). Author's collection. A large, stoutly built form with unusually long tegmina and remarkable cerci in the male. Fastigium lower, broader, less compressed than usual in the genus, and more widely separated from the frontal fastigium. Eyes widely separated, prominent, almost hemispherical. Dorsum of pronotum constricted at middle, the actual constriction exaggerated by the black band along each side, broader posteriorly than anteriorly. Lateral lobes of pronotum longer than deep. Tegmina appreciably longer than head and pronotum together, the stridulatory area extended to the apex. Suranale almost vertical, broadly linguiform; subgenital plate moderately produced, v-excised at apex, the angles acute. Cerci astoundingly specialized; the cercus at some distance from its aciculate apex is turned sharply inward and upward; just proximal to this bend the dorsal margin of the cercus bears a high, thin process, which is broad at its base but tapers to an acutely rounded apex; from the medial side of the base of the cercus there originates a great, sickle-shaped process which curves inward and upward across the tip of the body. These cultriform processes overlap and each reaches completely across the width of the body. Legs short and stout for the genus, the hind ones especially so. In color the specimen is mostly light green. The dorsum of head, thorax and abdomen dark brown, bordered on each side with black. There is also a fine black, median line on the front part of pronotum, ending at the transverse suture, which is v-shaped with its apex behind the middle of pronotum. Tegmina with the marginal field light green and yellow, discal area deep black, the veins green or light brown; stridulatory area mostly brown with the veins lighter. Knees, tarsi and apices of tibiae blackish. Antennae black, annulate with white. Measurements (mm.): pronotum, 5; tegmen, 8.4; front femur, 7; hind femur, 18.8; hind tibia, 22.7.

In their synopsis of the genus Rehn and Hebard (1914) did not recognize males of *mexicana* Brunner in their material and had only immature males of *durangensis*, described by them. From Brunner's description and notes furnished Rehn and Hebard, and from the latter authors' notes on immatures of *durangensis* I think it impossible that the insect now before me belongs to either of the two species. Apparently *cultricerca* represents the extreme development of the *tridactyla-caudelli* type but is unusual in cercal specialization and tegminal length. The type is unique.

**Dichopetala chirura** new species

*Type.*—Male, Valles, San Luis Potosi, VI-18-41 (Seevers and Dybas). Author's collection. A form of fairly robust body but with long and slender legs. Fastigium moderately compressed, well rounded (side to side) at apex, widely separated from frontal fastigium. Occiput evenly rounded. Eyes prominent, oval, their depth about one and a half times their width. Dorsum of pronotum a little constricted about the middle, where the transverse sulcus begins. The sulcus extends well behind the middle of pronotum as a u-shaped groove

with the bottom of the u minutely angulate. Tegmina as long as pronotum, the left one overlapping the entire dorsal breadth of the right one, obtusely rounded at apex of stridulatory vein. Subgenital plate rather strongly produced, carinate below, deeply v-excised at apex with the distal angles acutely rounded. Cercus with median edge weakly incurved to the minutely hooked, aciculate apex. External edge of cercus straight from base to about the middle, where a lobe



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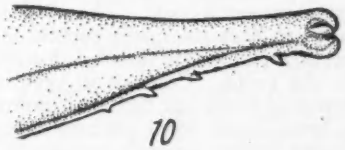

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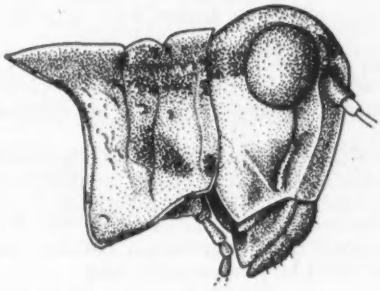

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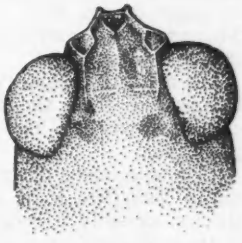

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FIG. 9. *Argyrtes maculatus* new sp., ovipositor of type.
FIG. 10. *Argyrtes maculatus* new sp., femoral spines of allotype
FIG. 11. *Trachyrhachis funeralis* new sp., head and pronotum of type.
FIG. 12. *Trachyrhachis funeralis* new sp., fastigium of type (other areas not in detail).

(median tooth of Rehn and Hebard, 1914) arises laterally. This lobe lies close to the distal part of the cercus, is broad at base, flattened and tapers evenly to the acutely rounded apex. The lobe reaches two-thirds or more of the distance from its origin to the apex of the cercus. The general color of the insect is light green, the dorsal surface minutely shagreen and dull. Head with a pale postocular bar on each side, which is continued along the pronotum. The tegmina have the stridulatory field dark brown, the veins lighter, the discal area

light green with the two longitudinal veins orange. Abdominal tergites marked with minute fuscous or reddish flecks. The hind tibia has a broad basal band and the apex black. All the tarsi are blackish, Measurements (mm.): pronotum, 4; tegmen, 3.9; front femur, 9.2; hind femur, 24.

*Allotype.*—Female, data identical with those for type. Pronotum not constricted at middle but broader posteriorly. Tegmina not attaining posterior margin of first abdominal tergite, the breadth one and a half times the length; the two tegmina are separated by an interval equal to half the breadth of one of them. Cerci conical. Subgenital plate completely divided, the apices acute but not aciculate. Ovipositor long, slender, gently curved from base to near apex, armed above near apex with six acute teeth, below with eight (including two small proximal ones). The ventral valve is strongly deflexed toward the apex so that its visible surface is almost horizontal; the submarginal teeth therefore are directed downward rather than laterally as is usual in the genus. Color as in type except that the light postocular and pronotal bands are bordered internally with black; behind each tegmen a broad black band appears on the abdomen and continues onto the fourth tergite, tapering posteriorly. The dark flecks of the abdominal tergites are more conspicuous than in the male type. Legs colored as in male except that the posterior femora are infuscated apically. Measurements (mm.): pronotum, 4.2; front femur, 11.6; hind femur, 26.3; ovipositor, 13.6.

In addition to the type and allotype I have at hand six males and two females from the same locality. All these have been carefully compared with the two specimens described above and are designated paratypes.

The specimens described and reported here were first identified by me as *pollicifera* R. & H., and *chirura* is very closely related to that species, possibly a geographic race of it, but the differences in cerci of the males and ovipositors warrant separate names for the two forms, Since the material available shows no intergradation between them, *chirura*, for the present at least, must be given specific rank.

## Acrididae (Oedipodinae)

### **Trachyrachis funeralis** new species

*Type.*—Male, Apatzingan, Michoacan, VIII-7-40 (Hoogstraal and Knight). Author's collection. A generally dark and obscurely colored locust with the face and hind femora paler. Head very little ascendant, cheeks not inflated, eyes large, elliptical but not much deeper than wide, their depth about equal to that of infraocular portion of gena. The infraocular sulcus arises below between two prominent ridges, which meet in a V. Frontal costa rather deeply sulcate for its entire length, parallel. Foveolae well marked, broadly triangular. Fastigium of vertex with its greatest width about equal to its length, considerably narrowed anteriorly and separated by a ridge from the frontal costa, its bounding walls thin and high. The disc of the fastigium is evenly depressed except for a short median ridge, which forks anteriorly.

The triangular area in front of and between the forks is flattened and considerable lower than the surface of the disc. Occiput with an ill-defined median ridge. Pronotum with the metazone half again as long as prozone, posterior lobe of prozone scutellate on the disc. Apex of metazone acutely rounded, a little less than a right angle. Median carina of pronotum low, not cristate, its middle lobe evenly rounded in profile. Posterior femur with upper carina evenly undulate, not suddenly elevated. Coloration generally dark with the face, fastigium, hind femora and two broad bands on pronotum umber. Hind femur with a considerable fuscous patch at the middle of the upper face and another patch beyond the middle. There are also several small flecks of dark color along the ventro-cephalic carina. Internal face of hind femur black with preapical, light band, lower sulcus light. Hind tibiae pale glaucous. Tegmina dark with irregular light markings. The wing is deep black, shading into blue in the axillary region. At the distal fourth of the wing an irregular, pellucid bar crosses the costal field and becomes evanescent on the first lobe. Measurements (mm.): body, 19.5; pronotum, 4; antenna, 12; tegmen, 20.6; hind femur, 12.5.

*Allotype.*—Female, data as for type. Larger, stouter and with proportionately shorter antennae than type. The dark color is more intensive and the lighter areas more strongly contrasting. The external face of the hind femur is marked with fuscous a little before the middle and the dark flecks along the lower carina are more extensive than in the male. On the tegmina the light areas appear as an irregular basal patch, a complete bar at basal two-fifths, and a narrow, incomplete bar just beyond the middle. The transverse, pellucid bar on the wing is visible across the costal area and first lobe and there are small clear areas along the wing margin. Measurements (mm.): body, 28.2; pronotum, 5.5; tegmen, 26; hind femur, 15.

In addition to the two specimens described there are at hand a male and female very similar to the type and allotype respectively. These bear the same data as the type and are designated paratypes.

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# A STUDY OF THE GENUS OCCEMYIA IN NORTH AMERICA
## (Diptera: Conopidae)[1]

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As a result of the study of some 850 specimens, including material from the larger collections in the country, a revision in the concepts of the species is proposed. Although far from the final word, it is believed that the present study will considerably reduce the difficulties well known to those who have attempted to identify the species.

Most of the confusion is due to deception in judging the female genital plate, and the importance attached to the proportions of the antennal segments and the length of the palpi. On the other hand, the color of the legs, particularly the hind femur, and the size, characters previously little used, have been found most valuable in defining the species. The primary reason for the difficulty of the genus, however, is the fact that the species are not highly differentiated, and many intermediate individuals occur. As a result, the species will be found to be defined by a combination of characters, most of which are matters of degree, and require experience and comparison of material for their correct evaluation.

The female genital plate is an important character, but the position in which the abdomen dries may make a short one appear long, and a long one appear short. Three dimensions are used here in describing this structure. The length is taken from the level where the edge of the membrane from the dorsal sclerite reaches the genital plate, to the tip. This constitutes the posterior length, whereas the anterior length may be much longer. It is the lack of recognition of this difference that has caused most of the confusion. On a specimen with the abdomen extended one sees the anterior length, while if the abdomen is flexed one sees the posterior length. As the anterior length cannot be seen in the normally flexed abdomen, it cannot be used for practical purposes. In hyperflexed specimens the posterior length cannot be estimated very well either, and such specimens may appear to have a very short genital plate. The width is taken as the distance between the points where the edges of the membranes from the dorsal sclerite meet the genital plate on each side. The thickness is estimated from the anterior to the posterior surfaces at the level where the width is measured.

Essentially three types of genital plates are found. The "long" type is present only in *propinqua*. It is definitely longer than wide,

[1]The sources of the material on which this paper is based have been acknowledged in another publication (Ent. News 54, 187, 1943). N. Banks, W. W. Barker, R. H. Beamer, and K. C. Doering have kindly supplied information on types; and E. C. Van Dyke sent paratypes of some of Van Duzee's species for comparison.

and is relatively thin. Only a narrow border is striated posteriorly. The "short" type of genital plate is present only in ***abbreviata***. It is definitely shorter than wide and is relatively thick. Striations are usually present over much of the posterior surface. The "medium" type is found in all of the other species. It is usually as long as wide, and intermediate in thickness and amount of posterior striations. The color of the long plate of ***propinqua*** is yellow with a dark margin, but this may be faded so that the entire plate is yellow. The other types are usually entirely black, but may be faded to brownish or yellowish. Within each of the three types of genital plates there is variation in the proportion to the width of the abdomen. These variations may be local or geographical, but show too much intergradation to be used at present in defining species.

The proportions of the segments of the antenna are variable, and not very reliable for the definition of species. In general the larger the species, or the individuals within a species, the longer the second segment is in proportion to the others. The palpi have also been found rather variable, both in the length and in the degree of being clavate. The length may be deceiving according to the way that the specimen has dried.

The proportion of black and yellow on the hind femur has been considered subject to great variation, but I have found it to be a relatively constant and reliable character, and have given it much importance in defining the species. The size also has been little used and it is well recognized that much variation may occur. However, I have found it of much value, especially in combination with other characters.

It is important to recognize teneral and faded specimens in which the black parts may be brownish or even quite yellow. All or only some of the black parts may be affected. In greasy specimens, the yellow parts may be reddish.

Local geographical variation has been found in some of the species, but when many specimens from many localities are seen the extent of intergradation makes their recognition by name of little value.

### **Occemyia propinqua** Adams

*Oncomyia propinqua* Adams, 1903, Kans. Univ. Sci. Bull. 2, 32 (no locality).
*Oncomyia angusticornis* Van Duzee, 1927, Proc. Calif. Ac. Sci. 16, 595 (Idaho: Moscow Mountain).
*Oncomyia longipalpis* Van Duzee, 1934, Ann. Ent. Soc. Am. 27, 321 (Washington: Spanaway).

This species is characterized by the long female genital plate, the prominence of white or yellowish hairs on the abdomen of typical males, the nearly (⅘) or entirely black hind femur, and the small size (3½–5½ mm., usually 4½ mm.). The antennal proportions are usually 1 : 2½ : 2, but are often 1 : 2 : 2. The palpi are usually 1–1½ times the first antennal segment. Males with yellow at the base of the hind femur and without prominent white hairs on the abdomen may not be distinguishable with certainty from ***nigripes***. The color of the hair on the abdomen is sometimes difficult to evaluate. Under certain lights all of the species have many white hairs. However, only in the

present species may very many long fine white or yellowish hairs be found. I have found the difference most distinct when the specimen is held with the tip of the abdomen away from the eye.

The name *propinqua* unquestionably belongs to this species. It is based on a male with entirely black femora, yellowish pilose abdomen, and 4.5 mm. in size. Five female paratypes of *angusticornis* have been examined and belong to this species. I have seen several mated pairs still together on the pin, and there can be no question that the males with many light hairs on the abdomen are the same species as the females with the long genital plate. The type of *longipalpis* has entirely black hind femora and long white hairs on the abdomen, so it belongs to this species. The main character "palpi a little longer than the first antennal joint" falls within the range of variation for this species. The paratype, however, which is described as having the basal half of the hind femora reddish and has been examined, belongs to *loraria*.

*Distribution.*—Southern Canada and United States; 320 specimens examined.

**Occemyia nigripes** new species

This species is characterized by the medium genital plate, the mainly (⅔–⅘, usually ¾) black hind femur, and the small size (3½–5½ mm., usually 4½ mm.). There are relatively few white hairs on the abdomen. The antennal segments are usually 1 : 2½ : 2 to 1 : 2 : 2. The palpi are 1–2 times the first antennal segment.

*Type.*—Female; Ontario: Thunder Bay Beach, Aug. 18, 1941; H. S. Parish; Camras Collection, deposited in the Chicago Natural History Museum.

Length, 4½ mm. Front black above, gradually shading to orange below, with a V-shaped mark of silvery pollen in the middle. Face and cheeks yellow with silvery pollen which extends narrowly up the frontal and posterior orbits. Facial grooves dusky. Occiput black with gray pollen. Antennal segments 1 : 2 : 2, yellow, with black externally on the first segment and upper portion of the second and third segments, and internally on the upper margin of the second and distal half of the third segment. Arista black. Proboscis black, first segment slightly longer than the second and about equal to the head height. Palpi black, somewhat clavate, 1½ times length of first antennal segment. Thorax black, with whitish pollen on dorsum and pleura. Abdomen black with whitish pollen on the distal borders of the segments and forming prominent patches on the sides of the second segment. Hairs mainly black, some whitish. Genital plate black, as long as wide, of medium thickness, and relatively large compared to the width of the abdomen. Wings dusky, veins black, yellow at base and calypters. Halteres yellow. Legs black with yellow on anterior coxae; narrowly at bases of anterior femora, tibia, and tarsi; bases of claws; and pulvilli. Basal ¼ of hind femur yellow.

*Allotype:* Male; same data and deposition as type, but collected March 15.

Practically identical with the type except for differences due to sex.

*Paratypes:* 132 specimens from Quebec, Ontario, Manitoba, all parts of the United States, and one from Guatemala (Helvetia, San Sebastian). Represented in various collections.

Four differentiation of males from ***propinqua*** see under that species. Specimens with one-third of the hind femur yellow cannot be distinguished with certainty from ***loraria***.

### **Occemyia nigra** Van Duzee

*Oncomyia nigra* Van Duzee, 1927, Proc. Calif. Acad. Sci. 16, 596 (Oregon: Corvallis).

This species is characterized by a medium genital plate, almost entirely (⅚–⅞) black hind femur, and large size (6½–7½ mm.). The antennal segments vary from 1 : 2 : 1½ to 1 : 3 : 2. The palpi are 2–2½ times the first antennal segment.

This species was described as having a very long female genital plate, and on superficial examination of the paratype which has been seen, this certainly appears to be the case. Closer scrutiny, however, reveals that this is an illusion due to the fact that the tip of the abdomen is hyperextended. The point where the edge of the membrane from the dorsal sclerite meets the genital plate indicates that the plate on this specimen would appear much shorter if the abdomen were normally flexed.

*Distribution.*—Maine (Rangeley), Oregon (Corvallis, Hood R.), and California (Antioch, Claremont, Los Angeles, Monterey). Nine specimens examined.

### **Occemyia loraria** Loew

*Oncomyia loraria* Loew, 1866, Berl. Ent. Zeitschr., Cent. VII 74 (New Hampshire).
*Oncomyia baroni* Williston, 1883, Trans. Conn. Acad. 6, 97 (California).
*Oncomyia brevirostris* Van Duzee, 1927, Proc. Calif. Ac. Sci. 16, 593 (Washington: Pullman).
*Oncomyia aequalis* Van Duzee, 1927, Proc. Calif. Ac. Sci. 16, 594 (California: Lower Lake, Lake Co.).
*Oncomyia terminalis* Van Duzee, 1927, Proc. Calif. Ac. Sci. 16, 594 (Oregon: Hood R.).
*Oncomyia frontalis* Van Duzee, 1934, Ann. Ent. Soc. Am. 27, 322 (Washington: Puyallup).

This species is characterized by the medium genital plate, the usually half black and half yellow (⅓–⅔) hind femur, and the medium size (3½–6 mm., usually 5 mm.). The antennal segments are most often 1 : 2½ : 2 or 1 : 2 : 2. The palpi are 1½ to 2½ times the first antennal segment. Individuals with more black on the hind femora may not be distinguishable from ***nigripes***, those with more yellow may not be distinguishable from ***luteipes***, and large individuals with more yellow on the hind femora and from the East cannot be told with certainty from ***longicornis***. The number of such intermediates, however, is relatively small.

From information on the type, the genital plate is medium and the hind femora half black and half yellow. The name, therefore, can only belong to this species. Information on the types of ***brevirostris***, ***aequalis***, ***terminalis***, and ***frontalis*** indicates that all of them belong to this species. The characters on which they are based all seem to

represent individual variation. The paratype of ***brevirostris*** and ***aequalis***, and the paratype of ***terminalis*** from Metaline Falls, Washington, have been examined. The paratype of ***terminalis*** from Pullman, Washington, belongs to ***luteipes*** and has been selected as the type of that species.

*Distribution.*—Southern Canada and United States; 170 specimens examined.

### **Occemyia longicornis** Say

*Myopa longicornis* Say, 1823, Jl. Acad. Nat. Sci. Phil. 3, 83; Compl. Writ. 2, 72 ("Missouri").

*Oncomyia infuscipes* Van Duzee, 1927, Proc. Calif. Ac. Sci. 16, 592 (Ontario: Kearney).

This species is characterized by the mainly yellow hind femur (terminal ⅓–¼ black), the large size (6½–8 mm., usually 7 mm.), and the medium genital plate. Antennal segments usually 1 : 2½ : 2, but frequently 1 : 2 : 1½. Palpi usually 1–1½ times the first antennal segment. Small specimens with much black on the hind femur may be difficult to distinguish from ***loraria***. In the females that species usually has a proportionally larger genital plate. Small males with less yellow may be difficult to distinguish from ***abbreviata***, but that species usually has the other legs more yellow.

The name ***longicornis*** based on a species "three-tenths of an inch" long (=7.6 mm.) and "posterior . . . thighs pale on basal moeity," is best applicable to this species. ***Modesta***, to which the name might also apply, is more western in distribution, and has less black on the legs than the description of ***longicornis*** implies. The paratype of ***infuscipes*** has been examined.

*Distribution.*—Southeastern Canada and Eastern United States, west of Colorado, New Mexico, and Arizona (one specimen with no other data); 43 specimens examined.

### **Occemyia modesta** Williston

*Oncomyia modesta* Williston, 1883, Trans. Conn. Acad. 6, 96 (Washington Territory).

This species is characterized by the entirely or almost entirely (⅘) yellow hind femur, the large size (6½–9 mm., usually 7½ mm.), and the medium genital plate. The antennal segments vary from 1 : 2 : 1½ to 1 : 2½ : 2. The palpi are 1–1½ times the first antennal segment.

This might be a geographical race of ***longicornis***, but there is some overlap in range without intergradation.

*Distribution.*—Southwestern Canada and Western United States east of Saskatchewan, Colorado, and New Mexico; 66 specimens examined.

### **Occemyia luteipes** new species

This species is characterized by the mainly yellow (⅔–⅘, usually ¾) hind femur, the small size (3½–5½ mm., usually 4½ mm.), and the medium genital plate. The antennal segments vary from 1 : 2½ : 2 to 1 : 2½ : 2½. The palpi are 2–2½ times the first antennal segment.

*Type:* Female; Washington: Pullman, July 11, 1925; C. L. Fox; California Academy of Sciences Collection No. 5423. Paratype of *Oncomyia terminalis* Van Duzee.

Length, 4½ mm. Front black on upper third and yellow on lower two-thirds, with V-shaped area of silvery pollen which is rectangular below. Face and cheeks yellow with silvery pollen which extends narrowly up the frontal and posterior orbits. Occiput black with gray pollen. Antennal segments 1 : 2 : 2, black with yellow on the inner surfaces of the second and proximal half of the third segment. Proboscis black, first segment slightly longer than the second and about equal to the head height. Palpi black, 2 times length of first antennal segment. Thorax black, with whitish pollen on dorsum and pleura. Abdomen black with whitish pollen on distal borders of the segments and forming prominent patches on the sides of the second segment. Hairs mainly black, some whitish. Genital plate black, as long as wide, relatively small compared to the width of the abdomen. Wings dusky, veins black, yellow at base and calypters. Halteres yellow. Legs yellow with black on the upper and outer half of the anterior femora, upper and outer fourth of the hind femora, distal two-thirds of the tibiae, and distal half of the tarsi and claws.

*Allotype*: Male; same data; California Academy of Sciences Collection No. 5424.

Similar to the type except for differences due to sex, but the yellow areas are more extensive (except on hind femora) and more sharply defined, the pollinose parts have more pollen, the antennal segments are 1 : 2½ : 2½, and the palpi are more clavate and 2½ times the first antennal segment.

*Paratypes:* 35 specimens from California, Washington, Idaho, Utah, and Colorado. Represented in various collections.

Specimens with much black on the hind femora cannot be distinguished with certainty from *loraria*. The few such specimens from the East have been referred to *loraria* until the occurrence of *luteipes* in the East can be definitely established.

### **Occemyia abbreviata** Loew

*Oncomyia abbreviata* Loew, 1866, Berl. Ent. Zeitschr., Cent VII 73 (District of Columbia).

*Oncomyia modesta* var. *melanopoda* Williston, 1885, Trans. Conn. Acad. 6, 393, 96 (Mt. Washington, White Mountains, New Hampshire).

This species is characterized by the short genital plate, the almost entirely (¾-⅘) yellow hind femur, and the medium size (5–6 mm.). The antennal segments are usually 1 : 2½ : 2, sometimes 1 : 2 : 2. The palpi are usually 2–2½ times the first antennal segment. Large males with much black on the hind femur cannot be distinguished with certainty from *longicornis*.

The type of *melanopoda* agrees most with a specimen of *abbreviata* sent for comparison.

*Distribution.*—Southeastern Canada and Eastern United States, west to South Dakota (Brookings); 82 specimens examined.

KEY TO THE NORTH AMERICAN SPECIES OF OCCEMYIA

1. Hind femur entirely to ⅛ black; female genital plate long; male abdomen usually with long white or yellowish hairs ..... **propinqua**
   Hind femur yellow on basal ⅛ or more; female genital plate never long; whitish hairs on abdomen not prominent ..... 2
2. Hind femur with yellow on the basal ⅛ to ⅓ ..... 3
   Hind femur with yellow on more than the basal ⅓ ..... 4
3. Small species; 3½ to 5½ mm. long ..... **nigripes**
   Large species: 6½ to 8 mm. long ..... **nigra**
4. Hind femur ⅓ to ⅔ yellow; side medium; 3½ to 6 mm. ..... **loraria**
   Hind femur over ⅔ yellow, or over 6 mm. long ..... 5
5. Size large: over 6 mm. long ..... 6
   Size smaller: 6 mm. or less ..... 7
6. Hind femur ⅔ to ¾ yellow ..... **longicornis**
   Hind femur ¾ to entirely yellow ..... **modesta**
7. Small species: 3½ to 5 mm. long; female genital plate medium ..... **luteipes**
8. Larger species: 5 to 6 mm. long; female genital plate short ..... **abbreviata**

## ADDENDUM

Since the above was written the author has visited the museums in the East and examined the types and cotypes of *loraria*, *baroni*, *modesta*, and *abbreviata*. No differences from the original interpretations of them were found.

*Zodion bimacula* Curran (1933, Amer. Mus. Nov., 673: 7—Ontario: Timagami) is based on an individual of *Occemyia loraria* in which the proboscis is broken off.

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EMOTIONAL FACTORS IN LEARNING, by Lois Barclay Murphy and Henry Ladd. x 404 pages. 1944. Columbia University Press. Price, $3.50.

Although the readers of the Annals are entomologists, many of them are also, through choice or necessity, teachers. As teachers they must have encountered among their undergraduate students the tantalizing and often baffling problems which arise in the work of individuals, and no matter how wisely each of us may meet such problems, he must often realize that he has not thoroughly understood his students nor adequately met their needs.

"Emotional Factors in Learning" takes up some of the more elusive personal matters which affect the work of college students. It is based on observations made at Sarah Lawrence College, hence it may be regarded as one-sided in so far as these problems are conditioned by sex, but it is, nevertheless, replete with vivid suggestions for the teacher who wishes to do everything possible for his students. Its first part considers diagnosis, interests and motivation, learning attitudes, orientation and growth, ways of development, the role of problems in learning, difficulties with specific types of work, patterns of personality, insecurity at the college level, authority problems and dynamic factors in learning. In the second part are presented studies of individual students. Among them the case of Julia, a biology student, is a vivid revelation of the complexity of the undergraduate.

The point of view of the book seems quite strongly that of the specially trained counselor. As the emphasis on this phase of college teaching increases it becomes an important question whether the teacher as such can fill both roles, and if he cannot, whether his more intuitional approach may be equally valuable if it is based on genuine interest and friendliness. Whatever the answer, no teacher can fail to find stimulation and help in this book. Since a recent writer on college work has accused the scientists of being especially remote from the majority of college students through emphasis on the importance of their subjects, possibly teachers of science need to consider these factors more carefully. To them the book will be well worth the time spent in reading it.—A. W. L.

# BIOLOGY OF IXODES DENTATUS NEUMANN (IXODIDAE)[1]

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*Ixodes dentatus* was named and illustrated in manuscript by Marx, but the first published description was by Neumann[2] in 1899, based only on the female. The male, nymph, and larva were described by Smith[3]. Nuttall[4] described all stages of a new variety of this species, *I. dentatus spinipalpis*, from western Canada. The typical *I. dentatus*, which differs from the variety *spinipalpis* in all stages, occurs in the eastern part of the United States and is the subject of this study.

## METHODS OF STUDY

Experimental studies on the biology of *Ixodes dentatus* were begun at Vineyard Haven, Mass., in June, 1938, with the use of specimens of all stages collected in nature or reared in the laboratory. Records on molting of engorged larvae and nymphs and on pre-oviposition, oviposition, and incubation of eggs from engorged females were obtained under outdoor conditions both in open sun and under shade from ticks kept in rearing tubes, and under incubator or room conditions from ticks kept in rearing tubes or in pill boxes set on moist sand. Records on the survival of unfed ticks of all stages under all conditions were obtained from ticks kept in rearing tubes.

The rearing tubes were prepared from test tubes of soft glass 6 inches long and ¾ inch wide. The glass bottoms were removed, and a new bottom was made by tamping in a moist mixture of clay, loam, and sand. This mixture conducts water readily, is firm, and will not draw away from the sides of the tube if it dries. The tubes were kept in pans of moist sand indoors and in the soil outdoors. Light cloth tops confined the ticks in the tubes but gave good ventilation and permitted rapid evaporation of excess moisture after rains.

The outdoor records were from tubes kept under two conditions so that the possibility of using abnormal records might be reduced. One lot of tubes was simply set in the soil to a depth of 2 inches where they would be exposed to direct sunlight and rainfall as well as to all variations

[1]A portion of a thesis submitted to the Graduate Council of The George Washington University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2]Neumann, G. 1899. Revision de la famille des Ixodidés. (3e memoire) Mem. Soc. Zool. France, 12: 107-294, illus.

[3]Smith, C. N. 1940. The male, nymph, and larva of *Ixodes dentatus* Marx (Acarina: Ixodidae). Ent. Soc. Wash. Proc. 42: 16–19.

[4]Nuttall, G. H. F. 1916. Notes on ticks. IV. Relating to the Genus *Ixodes* and including a description of three new species and two new varieties. Parasitology 8: 294–337, illus.

of temperature, humidity, and air circulation. The other lot was set in the soil under crates with roofing-paper tops, and sides of wood strips and screening, so that they were sheltered from direct rainfall and sunlight, but exposed to all variations of temperature, humidity, and air circulation. No great differences were noted between the records from the two locations—an indication that those from both were probably about normal.

All stages were engorged on cottontail rabbits confined in wire cages over pans of water into which the ticks dropped when they had completed feeding and from which they were collected daily. Records on seasonal abundance were based on collections of ticks from cottontail rabbits taken in nature.

TABLE I

SIZES OF FEMALES OF *Ixodes dentatus* USED FOR OUTDOOR OVIPOSITION RECORDS

| Female No. | Date of Dropping | Size of Female | | |
|---|---|---|---|---|
| | | Length, Mm. | Breadth, Mm. | Thickness, Mm. |
| | *1939* | | | |
| 51 | May 23 | 12.3 | 10.1 | 8.0 |
| 52 | 26 | 10.6 | 8.8 | 7.7 |
| 53 | 31 | 12.0 | 9.3 | 7.8 |
| | *1940* | | | |
| 176 | May 21 | 11.1 | 8.9 | 7.5 |
| 187 | 27 | 11.1 | 9.5 | 6.2 |
| 188 | 27 | 10.8 | 8.4 | 7.7 |
| 189 | 29 | 10.6 | 8.7 | 7.6 |

## LIFE HISTORY

*Oviposition.*—Daily oviposition records were obtained from seven females under outdoor conditions. The sizes of these ticks are shown in Table I, and the egg records in Table II. It will be noted that different ticks oviposited over periods of 12 to 38 days, with as many as 367 eggs deposited by one in a single day. The smallest total number of eggs deposited by a female was 398, the largest was 3,648, and the average for the seven was 2,092. Each female died a few days after oviposition was completed.

*Preoviposition, incubation, and larval survival.*—Records on the preoviposition, incubation, and larval survival were obtained under outdoor conditions from females that completed engorgement at various intervals from April to August. They are presented in Table III, together with records on three specimens maintained at a constant temperature of 80° F. The preoviposition period ranged from 7 to 24 days under outdoor conditions and from 8 to 13 days in the incubator. Incubation required only 33 to 38 days in the incubator, but from 47 to 66 days outdoors. The earliest hatching outdoors began July 28, and the eggs from all the females dropped before August 7 began hatch-

ing November 20 or earlier. As few females are active in nature after August 1, few engorged females or egg masses are exposed to winter.

TABLE II

DAILY OUTDOOR OVIPOSITION RECORDS OF SEVEN FEMALES OF *Ixodes dentatus*

| Day After Dropping | NUMBER OF EGGS LAID BY FEMALE NO.— | | | | | | |
|---|---|---|---|---|---|---|---|
| | 51 | 52 | 53 | 176 | 187 | 188 | 189 |
| 12 | ..... | ..... | ..... | ..... | ..... | 61 | ..... |
| 13 | 65 | ..... | 26 | ..... | ..... | 0 | 97 |
| 14 | 64 | 12 | 51 | ..... | 54 | 103 | 56 |
| 15 | 15 | 56 | 89 | ..... | 56 | 86 | 104 |
| 16 | 133 | 87 | 83 | ..... | 68 | 136 | 138 |
| 17 | 134 | 111 | 77 | ..... | 119 | 166 | 144 |
| 18 | 148 | 95 | 38 | ..... | 95 | 46 | 100 |
| 19 | 225 | 136 | 13 | ..... | 95 | 99 | 146 |
| 20 | 279 | 102 | 29 | 66 | 123 | 183 | 171 |
| 21 | 181 | 88 | 28 | 18 | 161 | 169 | 86 |
| 22 | 262 | 78 | 31 | 43 | 65 | 77 | 208 |
| 23 | 188 | 53 | 36 | 48 | 172 | 149 | 138 |
| 24 | 214 | 7 | 30 | 36 | 149 | 170 | 64 |
| 25 | 174 | 3 | 29 | 29 | 44 | 73 | 74 |
| 26 | 119 | [1] | 19 | 37 | 68 | 89 | 104 |
| 27 | 61 | ..... | 45 | 29 | 22 | 98 | 98 |
| 28 | 6 | ..... | 37 | 14 | 96 | 116 | 80 |
| 29 | 367 | ..... | 32 | 36 | 108 | 80 | 71 |
| 30 | 121 | ..... | 36 | 40 | 79 | 60 | 103 |
| 31 | 79 | ..... | 52 | 2 | 118 | 114 | 86 |
| 32 | 146 | ..... | 40 | 0 | 92 | 50 | 93 |
| 33 | 102 | ..... | 55 | 0 | 83 | 113 | 51 |
| 34 | 53 | ..... | 51 | [1] | 76 | 47 | 101 |
| 35 | 73 | ..... | 45 | ..... | 164 | 56 | 68 |
| 36 | 70 | ..... | 53 | ..... | 68 | 69 | 66 |
| 37 | 70 | ..... | 43 | ..... | 35 | 98 | 67 |
| 38 | 64 | ..... | 73 | ..... | 95 | 75 | 66 |
| 39 | 87 | ..... | 63 | ..... | 61 | 75 | 58 |
| 40 | 45 | ..... | 31 | ..... | 58 | 47 | 75 |
| 41 | 35 | ..... | 17 | ..... | 65 | 68 | 57 |
| 42 | 34 | ..... | 18 | ..... | 47 | 46 | 46 |
| 43 | 15 | ..... | 8 | ..... | 18 | 28 | 66 |
| 44 | 14 | ..... | 7 | ..... | 53 | 0 | 37 |
| 45 | 5 | ..... | 3 | ..... | 8 | 1 | 46 |
| 46 | 0 | ..... | 3 | ..... | 1 | [1] | 16 |
| 47 | 0 | ..... | 0 | ..... | 2 | ..... | 14 |
| 48 | [1] | ..... | [1] | ..... | 5 | ..... | 0 |
| 49 | ..... | ..... | ..... | ..... | 0 | ..... | 8 |
| 50 | ..... | ..... | ..... | ..... | 0 | ..... | 6 |
| 51 | ..... | ..... | ..... | ..... | [1] | ..... | [1] |
| Total | 3,648 | 828 | 1,291 | 398 | 2,623 | 2,848 | 3,009 |

[1]Female died.

In the incubator larvae lived for more than 153 days without feeding, whereas under outdoor conditions one lot lived for more than 621 days and all lots lived for over 300 days. Larvae that had fasted for 284 days engorged satisfactorily when placed on a host.

## TABLE III

PREOVIPOSITION, INCUBATION, AND LARVAL LONGEVITY OF *Ixodes dentatus*

| Date Female Dropped | Date of First Oviposition | Date of First Hatch | Date Some Larvae Were Last Seen Alive | Date All Larvae Were Dead | Preoviposition Period, Days | Incubation Period, Days | Larval Longevity, Days |
|---|---|---|---|---|---|---|---|
| *1938* | *1938* | *1938* | | | | | |
| June 1[1] | June 14 | July 22 | Dec. 22, 1938 | Jan. 3, 1939 | 13 | 38 | 153–165 |
| June 1[1] | June 9 | July 17 | Aug. 12, 1938[2] | | 8 | 38 | |
| June 1[1] | June 10 | July 13 | Sept. 13, 1938[3] | | 9 | 33 | |
| *1939* | *1939* | *1939* | | | | | |
| May 23 | June 5 | Aug. 3 | May 9, 1940[3] | | 13 | 59 | |
| May 26 | June 9 | Aug. 7 | June 14, 1940 | July 18, 1940 | 14 | 59 | 312–346 |
| May 31 | June 13 | Aug. 10 | Sept. 18, 1940 | Oct. 15, 1940 | 13 | 58 | 405–432 |
| Aug. 4 | Aug. 11 | Oct. 10 | Jan. 9, 1941 | Mar. 14, 1941 | 7 | 60 | 457–521 |
| *1940* | *1940* | *1940* | | | | | |
| Apr. 18 | May 10-June 3 | Aug. 2 | Apr. 15, 1942 | May 15, 1942 | | | 621–651 |
| Apr. 22 | May 10-June 3 | July 28 | July 15, 1941 | Aug. 14, 1941 | | | 352–382 |
| Apr. 27 | May 10-June 3 | Aug. 1 | Aug. 26, 1940[3] | | | | |
| Apr. 28 | May 10-June 3 | Aug. 1 | Mar. 17, 1942 | Apr. 15, 1942 | | | 593–622 |
| Apr. 29 | May 10-June 3 | Aug. 2 | Jan. 19, 1942 | Feb. 18, 1942 | | | 535–565 |
| Apr. 29 | May 10-June 3 | July 31 | Oct. 6, 1941 | Nov. 5, 1941 | | | 432–462 |
| Apr. 29 | May 10-June 3 | July 30 | Dec. 9, 1941 | Jan. 19, 1942 | | | 497–538 |
| Apr. 29 | May 10-June 3 | Aug. 1 | Dec. 9, 1941 | Jan. 19 ,1942 | | | 495–536 |
| Apr. 29 | May 10-June 3 | July 28 | Aug. 14, 1941 | Sept. 15, 1941 | | | 382–414 |
| May 4 | May 10-June 3 | July 29 | Oct. 6, 1941 | Nov. 5, 1941 | | | 434–464 |
| May 5 | May 10-June 3 | July 29 | July 15, 1941 | Aug. 14, 1941 | | | 351–381 |
| May 6 | May 10-June 3 | Aug. 4 | Aug. 26, 1940[3] | | | | |
| May 6 | May 10-June 3 | Aug. 8 | Dec. 9, 1941 | Jan. 19, 1942 | | | 488–529 |
| May 6 | May 10-June 3 | Aug. 8 | [3] | | | | |
| May 6 | May 10-June 3 | July 28 | June 17, 1941 | July 15, 1941 | | | 324–352 |
| May 6 | May 10-June 3 | July 29 | June 17, 1941 | July 15, 1941 | | | 323–351 |
| May 8 | May 10-June 3 | July 29 | Aug. 14, 1941 | Sept. 15, 1941 | | | 381–413 |
| May 8 | May 10-June 3 | Aug. 3 | Aug. 15, 1940[3] | | | | |
| May 8 | May 10-June 3 | July 28 | Sept. 15, 1941 | Oct. 6, 1941 | | | 414–435 |
| May 8 | May 10-June 3 | Aug. 7 | Jan. 19, 1942 | Feb. 18, 1942 | | | 530–560 |
| May 8 | May 10-June 3 | Aug. 4 | July 15, 1941 | Aug. 14, 1941 | | | 345–375 |
| May 8 | May 10-June 3 | Aug. 6 | Dec. 9, 1941 | Jan. 19, 1942 | | | 490–531 |
| May 15 | May 15-June 3 | Aug. 6 | Nov. 5, 1941 | Dec. 9, 1941 | | | 456–490 |
| May 15 | May 15-June 3 | Aug. 4 | Dec. 9, 1941 | Jan. 19, 1942 | | | 492–533 |
| May 15 | May 15-June 3 | July 29 | Aug. 26, 1940[3] | | | | |
| May 21 | June 7 | Aug. 9 | Jan. 19, 1942 | Feb. 18, 1942 | 17 | 63 | 528–558 |
| *1940* | *1940* | *1940* | | | | | |
| May 21 | June 14 | Aug. 12 | Aug. 14, 1941 | Sept. 15, 1941 | 24 | 59 | 367–399 |
| May 24 | June 7 | Aug. 9 | Oct. 6, 1941 | Nov. 5, 1941 | 14 | 63 | 423–453 |
| May 24 | June 7 | Aug. 5 | Aug. 14, 1941 | Sept. 15, 1941 | 14 | 59 | 374–406 |
| May 29 | June 13 | Aug. 18 | Sept. 15, 1941 | Oct. 6, 1941 | 15 | 66 | 393–414 |
| May 30 | June 13 | Aug. 13 | June 17, 1941 | July 15, 1941 | 14 | 61 | 308–336 |
| May 30 | June 17 | Aug. 15 | Dec. 9, 1941 | Jan. 19, 1942 | 18 | 59 | 481–522 |
| June 10 | June 24-July 2 | Aug. 20 | Nov. 5, 1941 | Dec. 9, 1941 | | | 442–476 |
| June 10 | June 24-July 2 | Aug. 24 | June 4, 1941[3] | | | | |
| June 12 | June 24-July 2 | Aug. 19 | July 15, 1941 | Aug. 14, 1941 | | | 330–360 |
| July 2 | July 17 | Sept. 2 | [3] | | 15 | 47 | |
| July 4 | July 8-July 15 | Sept. 1 | Dec. 9, 1941 | Jan. 19, 1942 | | | 464–505 |
| July 10 | July 20 | Sept. 6 | Sept. 15, 1941 | Oct. 6, 1941 | 10 | 48 | 374–395 |
| July 10 | July 21 | Sept. 15 | [3] | | 11 | 56 | |
| July 13 | July 22 | Sept. 11 | Dec. 9, 1941 | Jan. 19, 1942 | 9 | 51 | 454–495 |
| July 15 | July 23 | Sept. 20 | [3] | | 8 | 59 | |
| Aug. 3 | Aug. 11 | Oct. 15-Nov. 20 | [3] | | 8 | | |
| | | *1941* | | | | | |
| Aug. 7 | Aug. 16 | Jan. 9-Mar. 14 | Mar. 17, 1942 | Apr. 15, 1942 | 9 | | |

[1]Kept in incubator at 80 F. All others kept outdoors.
[2]Engorged.
[3]Alive May 15, 1942.

*Larval engorgement.*—Larvae were readily induced to feed on cottontail rabbits in the laboratory, and experimental engorgement records were obtained on 10,656 ticks, as listed in Table IV. A few larvae engorged in as short a period as 4 days, while one required 13 days. The majority completed engorgement in 6 days, and the average feeding period for the entire group was 6.3 days.

The larvae showed no tendency to drop at any particular hour of the day, even though dropping extended over a considerable period. In the two cases where this was investigated, approximately twice as

TABLE IV

ENGORGEMENT OF LARVAE OF *Ixodes dentatus*

| Date Larvae Were Put on Host | NUMBER OF LARVAE THAT DROPPED ENGORGED ON SPECIFIED DAY AFTER ATTACHMENT | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Total |
| *1938* | | | | | | | | | | | |
| Aug. 12 | ..... | 2 | 30 | 5 | ..... | ..... | ..... | ..... | ..... | ..... | 37 |
| Aug. 12 | ..... | 29 | 96 | 34 | 12 | 3 | ..... | ..... | ..... | ..... | 174 |
| Sept. 13 | ..... | 1 | 25 | 28 | 4 | 2 | ..... | ..... | ..... | ..... | 60 |
| *1939* | | | | | | | | | | | |
| Sept. 21 | 11 | 106 | 211 | 127 | 7 | ..... | ..... | ..... | ..... | ..... | 462 |
| Sept. 27 | ..... | 141 | 352 | 206 | 22 | 10 | ..... | ..... | ..... | ..... | 731 |
| Oct. 10 | ..... | 46 | 116 | 247 | 36 | 8 | 1 | ..... | ..... | ..... | 454 |
| Nov. 27 | 6 | 7 | 282 | 189 | 24 | 0 | 1 | ..... | ..... | ..... | 509 |
| Dec. 8 | ..... | 37 | 99 | 41 | 28 | ..... | ..... | ..... | ..... | ..... | 205 |
| *1940* | | | | | | | | | | | |
| Feb. 8 | ..... | ..... | 9 | 134 | 343 | 49 | 26 | 5 | ..... | ..... | 566 |
| May 9 | ..... | 1 | 54 | 139 | 17 | 2 | ..... | ..... | ..... | ..... | 213 |
| May 29 | ..... | ..... | 2 | 6 | 27 | 12 | 1 | ..... | ..... | ..... | 48 |
| June 11 | ..... | 1 | 17 | 46 | 51 | 8 | 4 | ..... | ..... | ..... | 127 |
| July 12 | ..... | ..... | 92 | 76 | 9 | 1 | ..... | ..... | ..... | ..... | 178 |
| Sept. 4 | ..... | 53 | 396 | 556 | 85 | 12 | 2 | 1 | 1 | 1 | 1,107 |
| Sept. 13 | ..... | 30 | 999 | 301 | 4 | ..... | ..... | ..... | ..... | ..... | 1,334 |
| Sept. 20 | 9 | 381 | 1,714 | 225 | 3 | 1 | ..... | ..... | ..... | ..... | 2,333 |
| Sept. 25 | ..... | 97 | 1,541 | 471 | 7 | 2 | ..... | ..... | ..... | ..... | 2,118 |
| Total | 26 | 932 | 6,035 | 2,831 | 679 | 110 | 35 | 6 | 1 | 1 | 10,656 |

many larvae dropped during the 16 hours between 5 P. M. and 9 A. M. as dropped during the 8 hours from 9 A. M. to 5 P. M. The actual numbers were 788 and 373, respectively.

The average dimensions of 20 fully engorged larvae were 1.33 mm. from the tip of the hypostome to the posterior extremity, 1.05 mm. across the body laterally at the widest part, and 0.70 mm. dorsoventrally at the thickest part. The largest specimen measured 1.41 by 1.05 by 0.72 mm. and the smallest measured 1.23 by 1.02 by 0.69 mm.

*Larval molting.*—Records on the molting of larvae under outdoor conditions are presented in Table V. In the case of larvae that dropped from April through August, the period from dropping to molting ranged from 34 to 110 days, being extended by low temperatures. Larvae

that dropped in September did not molt until the following summer, showing periods of 296 to 317 days. As larvae are active in nature until November, many evidently hibernate in the engorged condition.

TABLE V

LARVAL MOLTING OF *Ixodes dentatus* UNDER OUTDOOR CONDITIONS

| Date of Dropping | Number of Larvae | Date First Larva Molted | Date Last Larva Molted | Period From Dropping to Molting | |
|---|---|---|---|---|---|
| | | | | Minimum, Days | Maximum, Days |
| *1939* | | *1940* | *1940* | | |
| Sept. 19 | 3 | July 20 | July 22 | 305 | 307 |
| Sept. 20 | 17 | June 24–July 3 | ..... | ..... | ..... |
| Sept. 21 | 49 | July 17 | July 24 | 300 | 307 |
| Sept. 22 | 44 | June 24–July 3 | ..... | ..... | ..... |
| Sept. 25 | 11 | July 17 | July 27 | 296 | 306 |
| Sept. 26 | 106 | July 3–July 6 | ..... | ..... | ..... |
| Sept. 27 | 185 | July 21 | Aug. 9 | 298 | 317 |
| Sept. 28 | 143 | July 8–July 15 | ..... | ..... | ..... |
| Dec. 13 | 37 | July 26 | July 31 | 226 | 231 |
| Dec. 14 | 99 | July 8–July 15 | ..... | ..... | ..... |
| *1940* | | | | | |
| April 8 | 8 | July 3–July 6 | ..... | ..... | ..... |
| April 9 | 10 | July 8–July 15 | ..... | ..... | ..... |
| April 28 | 16 | July 23 | Aug. 5 | 86 | 99 |
| April 29 | 7 | July 22 | July 30 | 84 | 92 |
| May 6 | 63 | July 15 | July 31 | 70 | 86 |
| May 8 | 110 | July 26 | Aug. 26 | 79 | 110 |
| May 15 | 54 | July 24 | Aug. 31 | 70 | 108 |
| May 16 | 139 | July 24 | Aug. 16 | 69 | 92 |
| May 24 | 8 | July 28 | Aug. 8 | 65 | 76 |
| June 6 | 27 | July 30 | Aug. 9 | 54 | 64 |
| June 7 | 12 | July 31 | Aug. 6 | 54 | 60 |
| June 17 | 17 | Aug. 7 | Aug. 14 | 51 | 58 |
| June 18 | 47 | Aug. 7 | Aug. 22 | 50 | 65 |
| June 19 | 51 | Aug. 7 | Aug. 27 | 49 | 69 |
| July 2 | 43 | Aug. 12 | Aug. 27 | 41 | 56 |
| July 4 | 14 | Aug. 16 | Aug. 22 | 43 | 49 |
| July 5 | 8 | Aug. 16 | Aug. 27 | 42 | 53 |
| July 18 | 92 | Aug. 26 | Sept. 14 | 39 | 58 |
| July 19 | 76 | Aug. 29 | Sept. 14 | 41 | 57 |
| July 20 | 9 | Aug. 30 | Sept. 6 | 41 | 48 |
| July 30 | 41 | Sept. 16 | Oct. 13 | 48 | 75 |
| July 31 | 150 | Sept. 3 | Sept. 17 | 34 | 48 |
| Aug. 1 | 111 | Sept. 18 | Oct. 15 | 48 | 75 |
| Aug. 2 | 43 | Sept. 18 | Oct. 2 | 47 | 61 |
| Aug. 17 | 250 | Oct. 2 | ..... | 46 | ..... |
| Aug. 17 | 250 | Oct. 2 | ..... | 46 | ..... |
| | | *1941* | | | |
| Sept. 2 | 100 | June 17–July 15 | ..... | ..... | ..... |
| Sept. 2 | 100 | June 17–July 15 | ..... | ..... | ..... |

*Survival of unfed nymphs.*—Observations on the survival of unfed nymphs were disrupted by the transfer of the author from Massachusetts to Savannah, Ga., in 1942. The tubes containing live ticks were removed from their natural environment on May 15 of that year

and were not re-examined until August 26, having been kept in shipping cans and under other unnatural conditions in the meantime. Of the 36 lots in Table V shown to have molted to nymphs in 1940, 34 contained some live individuals on May 15, 1942, and 17 still contained live individuals on August 26, 1942. The longevity under natural conditions would therefore appear to be 2 years or more.

*Nymphal engorgement.*—The engorgement records of 693 nymphs are presented in Table VI. In each case the host was a cottontail rabbit. Thirteen individuals completed feeding in 4 days, whereas one required as much as 11 days. The majority engorged in 6 days, and the average feeding period was 5.7 days.

TABLE VI

ENGORGEMENT OF NYMPHS OF *Ixodes dentatus*

| Date Nymphs Were Put on Host | Number of Nymphs | NUMBER THAT DROPPED ENGORGED ON SPECIFIED DAY AFTER ATTACHMENT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total |
| *1938* | | | | | | | | | | |
| Oct. 12 | 50 | ..... | 10 | 18 | 3 | ..... | ..... | ..... | ..... | 31 |
| Oct. 19 | 22 | ..... | ..... | 2 | 4 | 0 | 1 | ..... | ..... | 7 |
| Nov. 30 | 269 | 3 | 12 | 4 | ..... | ..... | ..... | ..... | ..... | 19 |
| *1939* | | | | | | | | | | |
| July 13 | 100 | ..... | 40 | 9 | 1 | ..... | ..... | ..... | ..... | 50 |
| July 14 | 40 | ..... | 3 | 5 | 3 | 1 | ..... | ..... | ..... | 12 |
| Aug. 9 | many | 2 | 9 | 18 | ..... | ..... | ..... | ..... | ..... | 29 |
| Aug. 15 | 46 | ..... | 4 | 4 | ..... | ..... | ..... | ..... | ..... | 8 |
| Aug. 24 | 100 | ..... | 48 | 14 | 0 | 1 | ..... | ..... | ..... | 63 |
| Sept. 11 | 34 | 8 | 7 | 2 | ..... | ..... | ..... | ..... | ..... | 17 |
| *1940* | | | | | | | | | | |
| Feb. 8 | 40 | ..... | 2 | 11 | ..... | ..... | ..... | ..... | ..... | 13 |
| May 9 | 260 | ..... | 23 | 67 | 2 | 0 | 1 | ..... | ..... | 93 |
| May 29 | 355 | ..... | 48 | 210 | 14 | 3 | 0 | 1 | 1 | 277 |
| June 11 | 120 | ..... | 40 | 33 | 1 | ..... | ..... | ..... | ..... | 74 |
| Total.. | ..... | 13 | 246 | 397 | 28 | 5 | 2 | 1 | 1 | 693 |

Unlike the larvae, the nymphs showed a distinct tendency to drop during the daytime. In the two instances in which the time of dropping was investigated, only 4 nymphs dropped during the 16 hours from 5 P. M. to 9 A. M., while 76 dropped during the 8 hours from 9 A. M. to 5 P. M.

The average dimensions of 20 engorged nymphs, measured immediately after dropping in the same manner as were the larvae, were 2.30 by 1.64 by 1.11 mm. The dimensions of the largest nymph measured were 2.67 by 1.92 by 1.29 mm., and those of the smallest were 2.10 by 1.44 by 0.99 mm.

*Nymphal transformation period.*—Daily molting records were obtained under outdoor conditions from nymphs that completed engorgement at various intervals from April to October. Summaries of these records are presented in Table VII with records on adult longevity.

## TABLE VII

NYMPHAL TRANSFORMATION PERIOD AND ADULT LONGEVITY OF *Ixodes dentatus* UNDER OUTDOOR CONDITIONS

| Date of Dropping | Number of Nymphs | Date First Nymph Molted | Date Last Nymph Molted | Date Last Adult Died | Period from Dropping to Molting | | Adult Longevity, Days |
|---|---|---|---|---|---|---|---|
| | | | | | Minimum, Days | Maximum, Days | |
| *1938* | | *1938* | *1938* | | | | |
| Aug. 9 | 7 | Oct. 14-Nov. 17 | Oct. 14-Nov. 17 | May 22-June 17, 1941 | | | 917-977 |
| | | *1939* | *1939* | | | | |
| Sept. 29-Oct. 5 | 15 | July 8 | July 22 | Nov. 20, 1940-Jan. 9, 1941 | | | 487-551 |
| *1939* | | | | | | | |
| May 20 | 3 | July 26 | Aug. 3 | Aug. 15-Sept. 18, 1940 | 67 | 75 | 378-420 |
| May 23 | 2 | Aug. 3 | Aug. 3 | Dec. 9, 1941-Jan. 19, 1942 | 72 | 72 | 859-900 |
| July 16 | 2 | Sept. 4 | Sept. 10 | Nov. 20, 1940-Jan. 9, 1941 | 50 | 56 | 437-493 |
| | | *1940* | *1940* | | | | |
| July 18 | 10 | July 18 | July 24 | [1] | 366 | 372 | |
| | | *1939* | *1939* | | | | |
| July 18 | 30 | Aug. 24 | Oct. 6 | July 15-Aug. 14, 1941 | 37 | 80 | 648-721 |
| July 19 | 9 | Aug. 25 | Sept. 28 | June 17-July 15, 1941 | 37 | 71 | 628-690 |
| July 20 | 6 | Aug. 27 | Sept. 11 | May 22-June 17, 1941 | 38 | 53 | 619-660 |
| July 21 | 3 | Sept. 3 | Sept. 6 | Sept. 15-Oct. 6, 1941 | 44 | 47 | 740-764 |
| July 22 | 1 | Sept. 21 | Sept. 21 | Nov. 20, 1940-Jan. 9, 1941 | 61 | 61 | 426-476 |
| July 24 | 2 | Sept. 2 | Sept. 4 | Sept. 15-Oct. 6, 1941 | 40 | 42 | 742-765 |
| July 25 | 3 | Sept. 4 | Sept. 10 | Jan. 9-Mar. 14, 1941 | 41 | 47 | 487-557 |
| July 31 | 3 | Sept. 6 | Sept. 11 | Aug. 15-Sept. 18, 1940 | 37 | 42 | 339-378 |
| Aug. 1 | 4 | Sept. 10 | Sept. 15 | Mar. 14-Apr. 12, 1941 | 40 | 45 | 546-580 |
| Aug. 2 | 10 | Sept. 6 | Sept. 20 | Mar. 14-Apr. 12, 1941 | 35 | 49 | 541-584 |
| Aug. 14 | 9 | Sept. 24 | Oct. 3 | June 17-July 15, 1941 | 41 | 50 | 623-660 |
| Aug. 15 | 18 | Sept. 24 | Oct. 3 | Dec. 9, 1941-Jan. 19, 1942 | 40 | 49 | 798-848 |
| Aug. 20 | 4 | Oct. 4 | Oct. 10 | Aug. 14-Sept. 15, 1941 | 45 | 51 | 674-712 |
| Aug. 21 | 4 | Oct. 6 | Oct. 7 | Jan. 9-Mar. 14, 1941 | 46 | 47 | 460-525 |
| | | *1940* | *1940* | | | | |
| Aug. 30 | 45 | July 20 | Aug. 13 | Oct. 6-Nov. 5, 1941 | 325 | 349 | 419-473 |
| Sept. 15 | 8 | [2] | | [1] | 323 | 323 | |
| Sept. 16 | 7 | Aug. 4 | Aug. 4 | | | | |
| Sept. 17 | 2 | [2] | | | | | |
| Sept. 18 | 8 | July 18 | July 22 | Feb. 18-Mar. 17, 1942 | 304 | 308 | 576-607 |
| Sept. 19 | 4 | July 29 | Aug. 1 | [1] | 314 | 317 | |
| Sept. 20 | 10 | July 29 | Aug. 9 | [1] | 313 | 324 | |
| Sept. 21 | 10 | July 15 | July 27 | Oct. 6-Nov. 5, 1941 | 298 | 310 | 436-478 |
| Oct. 28 | 3 | July 26 | July 31 | [1] | 272 | 277 | |
| *1940* | | *1940* | *1940* | | | | |
| Apr. 8 | 3 | July 24 | July 29 | [1] | 107 | 112 | |
| Apr. 9 | 7 | Aug. 6 | Aug. 9 | [1] | 119 | 122 | |
| Apr. 28 | 5 | Aug. 6 | Aug. 22 | [1] | 100 | 116 | |
| Apr. 29 | 7 | July 31 | Aug. 7 | Sept. 15-Oct. 6, 1941 | 93 | 100 | 404-432 |
| May 6 | 35 | July 30 | Aug. 16 | [1] | 85 | 102 | |
| May 8 | 22 | Aug. 6 | Sept. 3 | [1] | 90 | 118 | |
| May 14 | 23 | Aug. 27 | Oct. 5 | Apr. 15-May 15, 1942 | 105 | 144 | 55.-626 |
| May 15 | 30 | Aug. 15 | Sept. 26 | [1] | 92 | 134 | |
| May 15 | 37 | Aug. 19 | Sept. 19 | Oct. 6-Nov. 5, 1941 | 96 | 127 | 382-443 |
| May 24 | 7 | Aug. 13 | Aug. 16 | Dec. 9, 1941-Jan. 19, 1942 | 81 | 84 | 480-524 |
| June 3 | 48 | Aug. 21 | Sept. 28 | [1] | 79 | 117 | |
| June 4 | 109 | Aug. 15 | Oct. 15 | [1] | 72 | 133 | |
| June 4 | 101 | Aug. 20 | Oct. 13 | [1] | 77 | 131 | |
| June 16 | 40 | Aug. 20 | Oct. 1 | [1] | 65 | 107 | |
| June 17 | 32 | Aug. 20 | Sept. 19 | [1] | 64 | 94 | |
| July 4 | 14 | Aug. 28 | Sept. 8 | [1] | 55 | 66 | |
| Aug. 14 | 16 | Oct. 14 | | [1] | 61 | | |

[1]Alive May 15, 1942.
[2]Nymphs died without molting.

It will be noted that the transformation period (the period from dropping of engorged nymphs to molting to adults) for nymphs that dropped from April to August, inclusive, ranged from 35 to 144 days, whereas nymphs that dropped late in the summer and in the fall did not molt until the following summer, after periods ranging as high as 372 days. As nymphs are active until November, many evidently hibernated in the engorged state. The earliest molting occurred July 8 in 1939 and July 15 in 1940, from overwintered nymphs in each case. Thereafter, molting to the adult form continued until the middle of October.

As the transformation periods of different individuals in the same lots varied as much as 61 days, the full records are too lengthy for tabular presentation, but the following general observations are based on 367 individuals that molted in 34 different lots exposed to outdoor conditions. The lots selected for this summary were of nymphs that dropped at intervals from April to August, inclusive. There were no differences between the transformation periods of those individuals producing males and those producing females. Of the 27 lots in which both sexes were produced, the individuals that molted on the first day were males in 10 cases, females in 15 cases, and of both sexes in 2 cases; the individuals that molted on the last day for each lot were males in 11 cases, females in 14 cases, and of both sexes in 2 cases. That is, 40 per cent of the minimum extremes and 44 per cent of maximum extremes were males, but as males represented 41.4 per cent of the total adults produced, this is about the proportion to be expected. Of the 367 individuals that molted, 152 produced males and 215, or 58.6 per cent, produced females.

*Adult longevity.*—Records of adult longevity are also presented in Table VII. Many adults that molted in 1940 were still alive when the study was terminated on May 15, 1942, but all those that molted in 1939 were dead. The extreme longevity observed was about 2½ years, most lots living for 1½ to 2 years. From one lot of 13 males and 5 females which were placed on a rabbit 2 years after they had molted from nymphs, 3 females engorged successfully and laid viable eggs.

*Adult engorgement and mating.*—Mating occurs on the host, but the males never attach to the host and feed. Males were often found in considerable numbers on rabbits captured alive, and invariably they were mating with the females or crawling about. In rearing experiments, males were placed on cottontail rabbits and their behavior observed. They were found to seek out and mate with any females present, sometimes remaining in the mating position for as long as 11 days. Males and females were kept together in rearing tubes and examined daily, but no mating was observed under these conditions, and it is probable that mating never occurs until after the females have attached themselves to the host. Females from such tubes, where they had been confined with males for many months, attached to rabbits and became partly engorged, but usually they would not complete engorgement until males had been placed on the host and had mated with them. However, one female which had access to males in the rearing tube, but not on the host, attached, engorged in 27 days, and began ovipositing within 2 weeks, but the eggs did not hatch. Successful fertilization was accomplished when the females had fed for as short a period as 4 days or as long a period as 40 days.

Possibly there is a correlation between the mating habits and nymphal molting. In this species and in ***Dermacentor variabilis*** (Say), both of which mate on the host, nymphs producing males and females molt in the same length of time, but more females are produced. In ***Ixodes muris*** Bishopp and Smith mating occurs on the ground and must precede feeding by the females, and in this species nymphs producing males molt earliest, and more males are produced than females.

Reared adults of ***Ixodes dentatus*** did not attach so readily as did those of some other species. Out of 29 females that were put on cottontail rabbits with males present only 14 engorged. Engorgement under these supposedly normal conditions required from 17 to 32 days, or an average period of 21.5 days. A cottontail rabbit that was released uninfested in a heavily infested area and recaptured between 24 and 48 hours later had become infested with 9 males and 12 females of ***Ixodes dentatus***. These females dropped engorged from 19 to 24 days after the rabbit had been released, showing an average engorging period of 20.9 days and agreeing closely with the average from reared adults.

The average dimensions of 49 engorged females, measured in the same manner as were the larvae immediately after dropping, were 11.1 by 8.7 by 7.6 mm. These records include females reared experimentally and those obtained from natural infestations. The dimensions of the largest female measured were 12.3 by 10.1 by 8.0 mm. and those of the smallest were 7.5 by 5.7 by 4.6 mm.

### HOSTS

The only hosts of ***Ixodes dentatus*** previously reported in the literature are rabbits, and in the course of this study rabbits were found to play an almost exclusive role. Fifty-six rabbits were captured alive at intervals from March through November, and caged over pans of water to permit all ticks to complete engorgement and drop, as described in the section on technique. The heaviest infestation occurred in May, 1940, when 733 larvae, 205 nymphs, 55 adult males, and 91 adult females were found on a single rabbit. The second heaviest infestation with 785 larvae and 9 nymphs occurred in October, 1938. Another rabbit carried 98 females, but not so many of the other stages. Larvae were found on 34 rabbits, nymphs on 50, males on 16, and females on 20. Only 3 rabbits were completely free of ticks. A total of 4,079 larvae, 932 nymphs, 240 adult males, and 422 adult females were collected from these hosts. Five rabbits caught in January and two caught in February were uninfested.

Several muskrats were captured in areas where ***Ixodes dentatus*** occurred, but only three were infested, one with a single larva, one with two larvae, and one with an adult male.

A single larva was found on a brown thrasher, but several towhees captured in the same locality were uninfested. As it seemed surprising to find a bird serving as a host, when even rodents other than rabbits were unsatisfactory, 100 larvae were placed on a towhee in a rearing cage, and 2 individuals engorged satisfactorily. Although large numbers of meadow mice and white-footed mice, many Norway rats, and many dogs from areas where the species was numerous were examined, none was found to be infested.

### SEASONAL ACTIVITY

Larvae were abundant in April, May, September, and October, but rare in June, July, and August. In the outdoor records on incubation (Table III) it was shown that hatching began late in July or in August, indicating that the larvae delay in becoming active, and that considerable hibernation of unengorged larvae occurs. Many engorged larvae also must hibernate, as Table V indicates that the larvae engorging in September and October would not molt until the following year.

Nymphs were about equally abundant at all times from April to October, although the two highest records were in May. As Table V shows no molting of engorged larvae before June, many flat nymphs must hibernate; and as Table VII shows that nymphs dropping in September would not molt until the following year, many others must hibernate in the engorged condition.

Females were most abundant in April, May, and June, although some activity continued until August. As Table VII shows no molting of nymphs before July, it seems evident that all adults, whether they molt from nymphs fed the same spring or the previous fall, hibernate in the unengorged state for one winter and become active the following spring. Attempts to feed adults experimentally also indicate that one winter of hibernation is required before they will feed, and it has been shown that unfed adults were able to survive at least two winters and two full seasons of activity. The records on incubation shown in Table III and those on seasonal abundance indicate that no engorged females would be exposed to winter, and no egg masses except in rare cases. It is doubtful whether the eggs in such cases would survive.

### PARASITIZATION BY IXODIPHAGUS TEXANUS HOW.

A rabbit captured August 2, 1938, at Oak Bluffs, Mass., was infested with 46 nymphs, 1 of which was parasitized. The parasites were permitted to emerge and were determined by A. B. Gahan, of the Bureau of Entomology and Plant Quarantine, as *Ixodiphagus texanus* How. Three parasites were produced. The species is normally parasitic in larvae and nymphs of the rabbit tick, *Haemaphysalis leporis-palustris* (Pack.). Several rabbits from the locality had carried parasitized individuals of the latter species.

### OVIPOSITION WITHOUT GENE'S ORGAN

In the course of normal oviposition the eggs are extruded through the genital opening by a membranous ovipositor, pushed across the depressed hypostome, and taken by a bilobed sac, Gené's organ, everted from under the scutum. Gené's organ is reported to apply the viscous coating which holds the eggs together in masses and prevents dessication. Various authors have reported that when Gené's organ was mutilated the eggs quickly became dry and shrivelled.

An engorged female that had apparently been scratched off by its host was collected from the dropping pan under a rabbit. A large piece of skin was still tightly clinging to the hypostome. In a short while the skin became hard and dry, and effectively prevented any approach of Gené's organ to the ovipositor and eggs. The female was kept in a pill box on moist sand and observed to deposit a normal number of eggs in a normal period of time. The eggs appeared to be normally cohesive, and the entire egg mass hatched satisfactorily.

# REACTIONS OF CERTAIN NYMPHS OF STENONEMA (EPHEMEROPTERA) TO LIGHT AS RELATED TO HABITAT PREFERENCE[1]

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Norris, Tennessee

In Douglas Lake, Michigan, nymphs of *Stenonema femoratum* (Say) and *S. interpunctatum* (Say) display almost identical habitat preferences and are especially numerous wherever rocks are found. In this lake rocky situations occur in shallow water and are almost invariably subject to severe wave action. In the natural environment the nymphs of these two species live under rocks during the day but were often observed on top of the rocks at night during calm weather; however, when a strong light was held on them for a short time, they would move to the lower surface.

Definite reactions were observed during the day. They do not appear to live normally on the substratum beneath the stones. Nymphs are not found on those rocks which have the under surface buried in the substratum. If a stone under which they occur is lifted from the water and suddenly turned over they immediately scurry to the under side. The immediate reactions are the same when a stone is merely lifted from the bottom and turned over but not removed from the water. They will, however, soon leave a rock held for a short time in this position, swim to the bottom, and seek a new stone under which they can find shelter. It should be noted that the nymphs are rather weak swimmers but they can move with agility when attached to an object.

Both species exhibit a strong, positive, thigmotactic response which is illustrated by their especially tenacious efforts to cling to a stone even when it is lifted free of the substratum and shaken vigorously in the water. This response was further demonstrated by placing a number of specimens in a circular aquarium with no object to which they could hold. At first they swam around the aquarium almost continuously but soon began to clasp one another until finally all clung together in a single group. Such a strong thigmotactic response is evidently correlated with the wave action factor of the rather vigorous environment in which they live.

From field observations it may be concluded that two factors, wave action and light, within the natural environment are the principal influences that cause these nymphs to seek a rocky habitat. But, since both species occur also under rocks in situations where waves are a minimal factor of the environment, and from their reactions in the natural habitat to light as described above, it is concluded that the nymphs do not live under rocks primarily because of the presence or absence of wave action. That light is the more important of the

[1]Contribution from the Biological Station and Department of Zoology, University of Michigan.

two factors in determining the habitat preference of rocks is further established by the following experiments.

The laboratory conditions did not appear to upset the normal reactions of the nymphs. About 20–25 individuals of one species were placed in a circular, glass culture-dish (30 × 10 cm.) with a marl-coated rock from their natural habitat and lake water. Each species was subjected separately to all experimental conditions. Under aquarium conditions the nymphs thrived, the younger ones showing distinct growth, the older ones coming to maturity and emerging. In the daytime they remained under the rock ventral side uppermost and attached to it but during the night the nymphs ranged freely over the upper surface of the stone. Very seldom did any of the nymphs leave

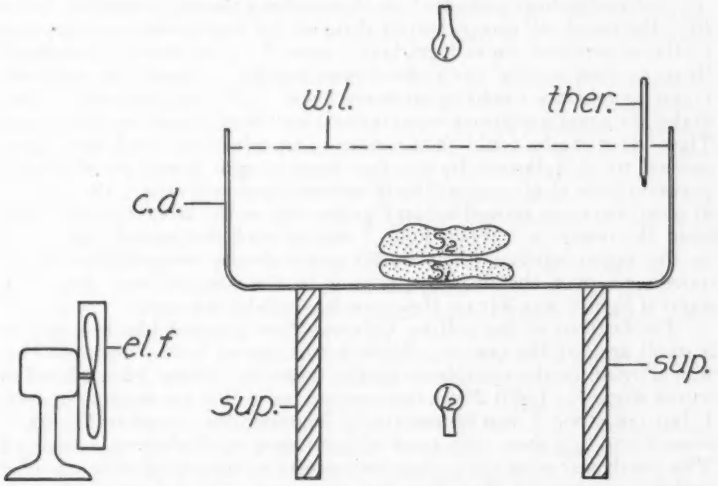


FIG. 1. $L_1$, light 1; $L_2$, light 2; ther., thermometer; c. d., culture dish; $S_1$, stone 1; $S_2$, stone 2; sup., support; el. f., electric fan for cooling light 2; w. l., water level.

the stone to swim around the aquarium. When a light was turned on at night, most of them would react quickly by moving to the lower surface. Their reactions to light were the same whether a clean stone or one covered with food was used.

Stomach examinations showed that the food of these nymphs consisted primarily of microscopic organisms associated with the marl-coated rocks of their natural environment. Feeding probably takes place only at night when the nymphs come to the upper surface of the stones. Very few were seen taking food during the day while under the stone even though food was available. It was difficult to make observations at night because of their negative reaction to any light, as soon as it was turned on, intense enough for such observations. However, most of those specimens on the upper surface at night which

did not react as rapidly as others to light were observed feeding. Food materials appeared to be more plentiful on the upper surface and sides of the rocks than directly under them. Since the presence of an adequate food supply must be considered as a possible factor limiting any given organism to a particular environment, the possibility was considered that these nymphs might be associated with the marl-coated rocks because of the lack of food elsewhere. However, the same food was available on the exposed sandy bottom near the rocks as occurred on the rocks themselves.

To further test their reactions to light, experiments were performed using the set-up as shown in Figure 1.

Nymphs chose the shadiest portion under the rock during the day although light entered from all sides. When the culture dish was covered with a heavy black cloth thus making the upper surface darker than the lower, all except two or three of the twenty-odd nymphs used in the experiment moved gradually around to the top and remained there as long as the cloth cover was present. When the cloth was taken away, they would again move below. The reactions were faster under the same conditions when lights 1 or 2 were turned on alternately. That the nymphs could detect movement when the cloth was raised seemed to be indicated by the fact that, if light 2 was on when that portion of the cloth nearest the observer was slowly raised, the nymphs in most instances moved around to the side of the stone furthest away from the observer. When light 2 was on and the nymphs had come to the upper surface, they would react almost immediately to any movement over the dish by moving to the sides of the stone. At night if light 1 was left on they remained under the rock.

The bottom of the culture dish was then painted black except for a small area at the center. Stone 1 was placed in the dish and time was allowed for the nymphs to gather under it. Stone 2 was placed on top of stone 1. Light 2 was then turned on so that the bottom of stone 1, but not stone 2, was illuminated. The nymphs moved to the top of stone 1 and in a short time most of them were on the bottom of stone 2. This result seems to show that they prefer to be ventral side up when under a stone, and that it is not necessarily the nature of the substratum which determines whether they choose to live ventral or dorsal side up, since in this instance the substratum was a stone in either case while in nature the substratum is sand.

## SUMMARY

1. Field observations on the reactions of certain *Stenonema* nymphs leads to the conclusion that a rocky habitat is selected primarily because of the two factors, wave action and light.

2. Experimental laboratory evidence is presented to show that of these two factors, the negative reaction to light is the more important.

3. It was shown that food was not a principal factor determining habitat preference.

# FURTHER ANALYSIS OF FECUNDITY IN THE FLOUR BEETLES, TRIBOLIUM CONFUSUM DUVAL AND TRIBOLIUM CASTANEUM HERBST.[1]

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During the past fifteen or so years the flour beetles *Tribolium* have been utilized so much in laboratory population studies (for summaries see Ford, 1937; Thomas Park, 1941) that it seems appropriate to place on record some new data on their fecundity which may be of value for future research. The present data were collected as part of a comprehensive analysis now in progress of inter-species competition in *Tribolium* populations.

In this paper, as in earlier investigations, we differentiate between "fecundity" and "fertility." By the former is meant egg production or rate of oviposition; by the latter, per cent of eggs hatching into first instar larvae. A cogent discussion of this distinction appears in Pearl and Surface (1909). The present paper contains no observations on fertility. This has been analyzed for *Tribolium confusum* (Park, 1936) and a report on *Tribolium castaneum* by another member of our laboratory is in preparation.

This study is concerned with the following three questions:

(1) What are the fecundity rates and variability of our stocks of *Tribolium confusum* and *Tribolium castaneum* under the particular conditions of experiment?

(2) Through selection, can a stock of either species be obtained that has an innately higher (or lower) rate of oviposition than the parents? In short, is there a genetic factor associated with reproduction?

(3) Is there more variability *between* pairs of beetles of both species than *within* pairs in respect of fecundity? (analysis of variance).

These questions will be discussed in the above order.

## MATERIAL AND METHODS

The general husbandry of *Tribolium* has been reviewed in a number of places and needs no elaboration here (Park, 1934). Suffice it to say that the flour-medium in which the beetles live can be sifted through silk bolting cloth thus separating the eggs from the flour for counting. The experimental beetles are grown in shell vials (9.5 cm. by 2.3 cm.) in a medium of fine-sifted whole-wheat flour[2] to which 5 per cent sifted brewers' yeast is added by weight. The yeast is thoroughly admixed through the flour by a mechanical rotating device. This precludes the chance of nutritional differences between one vial and another. The vials are kept in dark incubators at a mean temperature of 29° C., and

[1]This investigation was aided in part by a grant from the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago.

[2]The flour ("Elam's") and the yeast ("Fleischmann's") are passed through No. 8 bolting cloth which has 86 meshes to the inch.

at a relative humidity of 60 to 75 per cent. Our *Tribolium confusum* stocks have been maintained in the laboratory for 15 years and the *Tribolium castaneum* stocks for 11 years. Thus they are closely inbred and genetically homogeneous.

The experimental routine is as follows: One pair of beetles two to three weeks old is introduced into a vial containing four grams of medium. This vial, along with others like it, is lightly stoppered with cotton and placed in the incubator. After five days the contents of each vial are emptied into the sieve; the imagoes gently removed with a spatula and brush, and the medium passed through No. 5 bolting cloth. The eggs retained in the sieve are counted with the aid of a hand-tally and the number recorded. The beetles are returned to their respective vial to which four grams of fresh medium have been added (the old medium being discarded) and then put back into the incubator. It has been shown (Park and Woollcott, 1937) that "conditioning" of the flour by the population is an important factor in reducing fecundity. The effect is largely eliminated by this changing of the medium each five days.

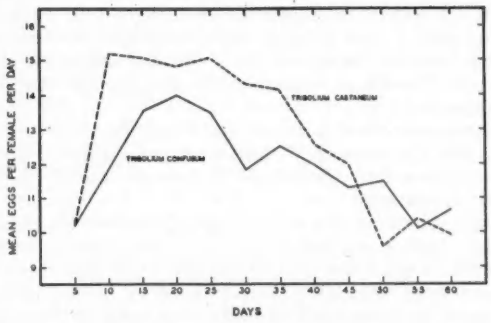


FIG. 1. Mean rate of oviposition of *Tribolium confusum* and *Tribolium castaneum* for 60 days of observation.

## THE PARENTAL FECUNDITY DATA

The parental data (hereafter called $P_1$) are records of the fecundity rates of 35 pairs of *Tribolium confusum* and 49 pairs of *Tribolium castaneum* over 12 five-day census periods. The data are summarized biometrically in Table I and the time-trends are plotted in figure 1.

From Table I a number of instructive points emerge, the most important of which are as follows:

(1) For both species the maximum fecundity is not attained by the five-day census. After 25 days fecundity gradually declines on the average as is well shown in figure 1. The oviposition rate from 0–30 days is significantly higher than that from 30–60 days. These are not new findings for *Tribolium confusum*.

(2) There is some tendency for the variability, as indexed by the coefficient of variation, to be lower during the intermediate periods and

higher towards the start and end of the experiment. In general, there is somewhat more variability, both actual and relative, for *Tribolium castaneum* than for *Tribolium confusum*. This is a significant difference since, when the standard deviations and coefficients of variation for the 60 day period are compared between species, the probability in both instances is less than 0.0000.

TABLE I

ANALYSIS OF FECUNDITY OVER A 60-DAY PERIOD OF THE $P_1$ GENERATION OF *Tribolium confusum* AND *Tribolium castaneum*

| Interval (days) | TRIBOLIUM CONFUSUM | | | | | TRIBOLIUM CASTANEUM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean eggs per female per 5 day period | $\sigma$ (eggs) | Coefficient of Variation (per cent) | Mean eggs per female per day | n | Mean eggs per female per 5 day period | $\sigma$ (eggs) | Coefficient of Variation (per cent) | Mean eggs per female per day | n |
| 0–5 | 51.2 ± 1.50 | 13.2 | 25.8 | 10.2 | 35 | 51.1 ± 1.73 | 18.0 | 35.2 | 10.2 | 49 |
| 5–10 | 68.8 ± 1.79 | 15.7 | 22.8 | 13.8 | 35 | 76.2 ± 1.20 | 12.5 | 16.4 | 15.2 | 49 |
| 10–15 | 68.1 ± 1.34 | 11.8 | 17.3 | 13.6 | 35 | 75.7 ± 1.31 | 13.6 | 18.0 | 15.1 | 49 |
| 15–20 | 70.2 ± 1.44 | 12.6 | 17.9 | 14.0 | 35 | 74.0 ± 1.26 | 13.1 | 17.7 | 14.8 | 49 |
| 20–25 | 67.6 ± 1.71 | 15.0 | 22.2 | 13.5 | 35 | 75.7 ± 1.39 | 14.4 | 19.0 | 15.1 | 49 |
| 25–30 | 58.9 ± 1.99 | 17.5 | 29.7 | 11.8 | 35 | 71.7 ± 1.35 | 14.0 | 19.5 | 14.3 | 49 |
| 0–30 | 64.2 ± 0.73 | 15.7 | 24.4 | 12.8 | 210 | 70.7 ± 0.67 | 17.0 | 24.0 | 14.1 | 294 |
| 30–35 | 62.3 ± 1.41 | 12.4 | 19.9 | 12.5 | 35 | 71.0 ± 1.60 | 16.6 | 23.4 | 14.2 | 49 |
| 35–40 | 60.2 ± 1.52 | 13.3 | 22.1 | 12.0 | 35 | 63.2 ± 1.63 | 16.9 | 26.7 | 12.6 | 49 |
| 40–45 | 56.4 ± 1.49 | 13.1 | 23.2 | 11.3 | 35 | 59.9 ± 1.85 | 19.2 | 32.1 | 12.0 | 49 |
| 45–50 | 57.4 ± 1.66 | 14.6 | 25.4 | 11.5 | 35 | 48.1 ± 2.14 | 22.2 | 46.1 | 9.6 | 49 |
| 50–55 | 50.6 ± 1.90 | 16.7 | 33.0 | 10.1 | 35 | 51.9 ± 2.15 | 22.3 | 43.0 | 10.4 | 49 |
| 55–60 | 53.6 ± 1.72 | 15.1 | 28.2 | 10.7 | 35 | 49.6 ± 2.25 | 23.4 | 47.2 | 9.9 | 49 |
| 30–60 | 56.8 ± 0.68 | 14.6 | 25.7 | 11.4 | 210 | 57.4 ± 0.85 | 21.6 | 37.6 | 11.5 | 294 |
| 0–60 | 60.4 ± 0.53 | 16.0 | 26.5 | 12.1 | 420 | 64.1 ± 0.57 | 20.4 | 31.8 | 12.8 | 588 |

| STATISTICAL COMPARISONS | MEAN DIFFERENCE | PROBABILITY |
|---|---|---|
| *Tribolium confusum* cf. *Tribolium castaneum* (total period) | 3.7 | 0.0012 |
| *T. confusum* (0–30) cf. *T. castaneum* (0–30) | 6.5 | 0.0000 |
| *T. confusum* (30–60) cf. *T. castaneum* (30–60) | 0.6 | >0.5 |
| *T. confusum* (0–30) cf. *T. confusum* (30–60) | 7.4 | 0.0000 |
| *T. castaneum* (0–30) cf. *T. castaneum* (30–60) | 13.3 | 0.0000 |

(3) In terms of total amount of egg-laying *Tribolium castaneum* oviposits at about a six per cent greater rate over the 60 days than does *Tribolium confusum*. This difference in relation to its probable error is significant. However, it is the relatively high rate of *Tribolium castaneum* for the first 30 days that accounts for most of the difference between the species. The oviposition from 30–60 days is not significant statistically.

In figure 2 we have plotted as frequency distributions the total (0–60 days) fecundity data for both *Tribolium confusum* and *Tribolium castaneum*. These curves are based on 420 vial examinations involving 25,393 eggs for the former and 588 vial examinations involving 37,684 eggs for the latter. These curves are roughly normal in character although by chi-square test they differ significantly from the theoretical frequencies expected on the basis of a normal probability distribution. The skewness can be better discerned by comparing the broken-line curves (theoretical) with the solid-line curves (observed). For *Tribolium confusum* there is left-skewness; for *Tribolium castaneum* right-skewness.

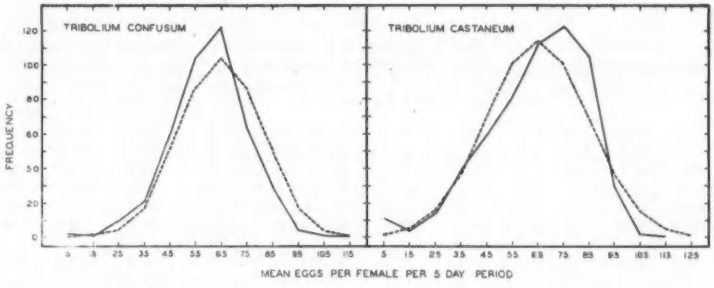


FIG. 2. Fecundity performance of the $P_1$ *Tribolium confusum* and *Tribolium castaneum* plotted as frequency distributions. The broken lines are approximations of normal probability curves fitted by the ordinate method. The maximum ordinate, $y_o$, is obtained from the formula $y_o = \frac{N\,i}{\sigma\sqrt{2\pi}}$ where N is the number of cases; i the class interval and $\sigma$ the standard deviation of the distribution.

## THE SELECTION EXPERIMENTS

Our interest in the selection experiments lay in trying to obtain high and low reproducing strains of both *Tribolium confusum* and *Tribolium castaneum*. In this attempt we were not completely successful but the data are interesting and completely new for flour beetles. The experimental procedure is simple and precisely similar for both species. The fecundity assay period in all generations is the second, third and fourth census: namely, the 10, 15 and 20 day counts. These are chosen because it is unnecessarily tedious to run the cultures for 60 days and because the $P_1$ data of Table I show that maximum reproduction and minimum variability obtain for these early periods. After the 20-day $P_1$ count the single pair producing the greatest and the pair producing the smallest number of eggs is determined. Eggs from these beetles then are removed respectively to large volumes of flour, allowed to develop and the progeny collected. These progeny, the $F_1$ imagoes, are set up in vials and their fecundity assayed in the usual way for 20 days. Thereupon

the selection is repeated to get $F_2$ imagoes for testing. This is continued until for *Tribolium castaneum* there are $P_1$, $F_1$, $F_2$ and $F_3$ assays for both high and low selected strains and for *Tribolium confusum* $P_1$, $F_1$ and $F_2$ assays for both strains. The data are summarized in Table II and graphed in figure 3.

TABLE II

THE EFFECT OF SELECTION ON THE FECUNDITY OF *Tribolium confusum* AND *Tribolium castaneum*

| THE DATA | | | | | STATISTICAL COMPARISON | | | |
|---|---|---|---|---|---|---|---|---|
| Generation | Mean eggs per female per 5 day period | $\sigma$ (eggs) | Coefficient of Variation (per cent) | n | Comparisons | Mean Difference | Larger member of compared pair | Probability |
| **TRIBOLIUM CASTANEUM** | | | | | | | | |
| P-1..... | 75.4 ± 0.65 | 12.6 | 16.7 | 171 | P-1 & F-1 H | 13.76 | F-1 H | <0.0000 |
| F-1 high... | 89.2 ± 1.11 | 15.4 | 17.3 | 87 | P-1 & F-1 L..... | 0.72 | F-1 L | >0.5 |
| F-1 low.... | 76.1 ± 1.40 | 18.3 | 24.0 | 78 | P-1 & F-2 H..... | 12.67 | F-2 H | <0.0000 |
| F-2 high... | 88.1 ± 1.51 | 19.8 | 22.5 | 78 | P-1 & F-2 L..... | 1.87 | F-2 L | 0.3450 |
| F-2 low.... | 77.3 ± 1.14 | 15.5 | 20.1 | 84 | P-1 & F-3 H..... | 8.99 | F-3 H | 0.0009 |
| F-3 high... | 84.4 ± 1.71 | 24.0 | 28.4 | 90 | P-1 & F-3 L..... | 9.07 | P-1 | <0.0000 |
| F-3 low.... | 66.4 ± 1.54 | 20.6 | 31.0 | 81 | F-1 H & F-1 L... | 13.04 | H | <0.0000 |
| | | | | | F-2 H & F-2 L... | 10.80 | H | <0.0000 |
| | | | | | F-3 H & F-3 L... | 18.06 | H | <0.0000 |
| | | | | | F-1 H & F-2 H.. | 1.09 | F-1 | >0.5 |
| | | | | | F-1 H & F-3 H.. | 4.77 | F-1 | 0.1208 |
| | | | | | F-2 H & F-3 H.. | 3.68 | F-2 | 0.2805 |
| | | | | | F-1 L & F-2 L... | 1.15 | F-2 | >0.5 |
| | | | | | F-1 L & F-3 L... | 9.79 | F-1 | 0.0015 |
| | | | | | F-2 L & F-3 L... | 10.94 | F-2 | <0.0000 |
| **TRIBOLIUM CONFUSUM** | | | | | | | | |
| P-1..... | 63.3 ± 1.06 | 18.4 | 29.1 | 138 | P-1 & F-1 H..... | 6.31 | P-1 | 0.0085 |
| F-1 high... | 56.9 ± 1.24 | 17.2 | 30.2 | 87 | P-1 & F-1 L..... | 6.50 | P-1 | 0.0019 |
| F-1 low.... | 56.8 ± 0.94 | 13.1 | 23.1 | 87 | P-1 & F-2 H..... | 18.86 | P-1 | <0.0000 |
| F-2 high... | 44.4 ± 1.49 | 21.0 | 47.3 | 90 | P-1 & F-2 L..... | 13.95 | P-1 | <0.0000 |
| F-2 low.... | 49.3 ± 1.07 | 14.8 | 30.0 | 87 | F-1 H & F-1 L.. | 0.19 | H | >0.5 |
| | | | | | F-2 H & F-2 L.. | 4.91 | L | 0.0686 |
| | | | | | F-1 H & F-2 H.. | 12.55 | F-1 | <0.0000 |
| | | | | | F-1 L & F-2 L... | 7.45 | F-1 | 0.0007 |

*Tribolium castaneum.* We were successful in obtaining through selection a high fecundity strain for *Tribolium castaneum.* Interestingly enough, the selection accomplishes its total effect in one generation; oviposition rate is not increased beyond the $F_1$ generation. From Table II we note that mean fecundity increases from a $P_1$ value of 75.4 eggs to an $F_1$ maximum of 89.2 eggs. This increase of about 15 per cent is highly significant. Thereafter the "high strain" remains significantly above both the $P_1$ and the "low strain."

Selection for low fecundity maintains, rather than reduces, the $P_1$ level through the $F_2$ generation. There is no significant difference between the means 75.4, 76.1 and 77.3. The fecundity drops decidedly in the $F_3$ generation but, since this is a drop also somewhat apparent in the $F_3$ highs, it may well be environmental rather than genetic.

Thus it appears that for ***Tribolium castaneum*** fecundity has some sort of a genetic basis as well as an environmental one. There is nothing startling in this conclusion; in fact, it would be more surprising if it were not so. Probably if our laboratory stock were more heterogeneous and had not been inbred for so many years we could have obtained through selection an even greater difference in fecundity.

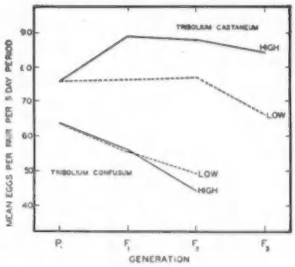


FIG. 3. Egg production by generations for *Tribolium confusum* and *Tribolium castaneum*.

***Tribolium confusum***. The selection data for ***Tribolium confusum*** are negative. They show no selection effect operating whatsoever. The curves of figure 3 immediately make the point that fecundity drops off significantly between the $P_1$, $F_1$ and $F_2$ generations irrespective of selection. There are no significant differences between "high" and "low" strains.

We do not conclude from these data that heredity has no influence on fecundity in this species. The presence of such an effect in ***Tribolium castaneum*** would suggest it for ***Tribolium confusum***. There are two obvious explanations of our ***Tribolium confusum*** findings. The first and most probable is that the selection was not carried on a wide enough scale. Had we selected rather than one pair a number of high and a number of low pairs in the $P_1$ generation and repeated this in later generations the chances of locating genes associated with reproduction would have been increased. This procedure might have yielded positive results. Also, there is the possibility that our ***Tribolium confusum*** stocks, highly inbred as they are, have their heredity in terms of fecundity so fixed that nothing remains to be selected. Further researches could answer these conjectures.

## ANALYSIS OF VARIANCE

In this section we are interested in breaking down the fecundity data in order to compare the variation existing ***between*** pairs of beetles

with that ***within*** pairs. This is a conventional analysis of variance problem. The data appear in Table III in which is tabulated the total variance of the sample, the variance between pairs, the variance within pairs and the probability that the latter two differ significantly one from the other. All oviposition records for both species are included.

TABLE III

ANALYSIS OF VARIANCE OF THE TOTAL FECUNDITY DATA

| Mating | Variance | | | Larger Variance | Probability |
|---|---|---|---|---|---|
| | Total | Between | Within | Smaller Variance | |
| **TRIBOLIUM CASTANEUM** | | | | | |
| P-1 (0-60 days) | 419.3 | 2140.4 | 266.1 | 8.04 | <1% |
| P-1 (5-20 days) | 160.79 | 371.07 | 57.49 | 6.45 | <1% |
| F-1 high | 240.44 | 547.22 | 92.33 | 5.93 | <1% |
| F-1 low | 337.90 | 778.4 | 108.5 | 7.2 | <1% |
| F-2 high | 399.47 | 930.1 | 144.36 | 6.44 | <1% |
| F-2 low | 243.08 | 494.18 | 122.01 | 4.05 | <1% |
| F-3 high | 585.76 | 1077.56 | 348.06 | 3.09 | <1% |
| F-3 low | 460.02 | 1004.19 | 198.01 | 5.07 | <1% |
| **TRIBOLIUM CONFUSUM** | | | | | |
| P-1 (0-60 days) | 250.2 | 919.3 | 191.1 | 4.8 | <1% |
| P-1 (5-20 days) | 341.67 | 851.24 | 92.43 | 9.21 | <1% |
| F-1 high | 301.92 | 452.51 | 229.22 | 1.97 | <1% |
| F-1 low | 176.09 | 182.04 | 173.22 | 1.05 | >5% |
| F-2 high | 439.40 | 1174.36 | 84.17 | 13.95 | <1% |
| F-2 low | 222.80 | 484.44 | 96.49 | 5.02 | <1% |

These data are straightforward and interesting. With one possible exception (the ***Tribolium confusum*** $F_1$ low) they show that there is significantly more variability in egg-laying between different pairs than there is within individual pairs. Differently put, this means that a ***Tribolium*** pair has a certain individualized pattern of oviposition that belongs more to itself than to its group as a whole. Thus, in general, we should expect to find more frequently females that are consistently high or intermediate or low ovipositors than we should females that were at one count, say, very high, the next count low, and so on. This is a point we have supposed to be true but it has not been demonstrated heretofore.

## SUMMARY

(1) Records of the oviposition of ***Tribolium confusum*** Duval and ***Tribolium castaneum*** Herbst over a 60 day period of observation are analyzed. It is shown that the latter species has a significantly higher fecundity rate by about six per cent than the former species. The variability is greater for ***Tribolium castaneum*** also.

(2) On the basis of selection of high and low strains of beetles it is possible to develop a stock of *Tribolium castaneum* with a 15 per cent greater fecundity rate than the parental generation. It was not possible to do this for *Tribolium confusum*. Some suggestions that may account for this failure are presented.

(3) Analysis of variance of the total data shows conclusively that there is more variability in respect of fecundity between pairs of beetles of both species than within pairs.

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THE BOOK OF NATURALISTS. Edited by WILLIAM BEEBE. 499 pp. 1944. A. A. Knopf, New York. Price, $3.50.

The sub-title ("An Anthology of the Best Natural History") to Dr. Beebe's new book best describes this enjoyable volume. The book consists of selections from the writings of naturalists from the time of Aristotle in the fourth century B. C. to Rachel L. Carson in the twentieth century (1941). Each selection is previewed by Dr. Beebe with an account of the writer's contribution to and place in the annals of natural history. They are not mere biographical sketches but rather are enlightening commentaries on the progress of natural history and natural history writing.

Like a discriminating connoisseur Dr. Beebe has sampled the writings of 45 different naturalists. Some of these are ancient, some are modern, some are famous and some are obscure, but all are pleasant refreshing reading. Their selection reflects at once the breadth of the author's interests, his familiarity with natural history literature and appreciation of the importance of expositional writing in posting the progress of science.

Two-thirds of the selections are from American and British authors. Nine other countries are represented by the remaining writers. The range of the subject matter includes plants, protozoa, mollusks, arthropods, fish, amphibians, reptiles, birds, mammals, evolution and general biological problems. The geographic range of the articles includes the United States, American tropics, southern South America, central Africa, Europe, Asia, Arctic and Anarctic regions and the bathosphere for which Dr. Beebe is famous.

In two introductory chapters the author presents a personal sketch of natural history writing and writers and sets up his concept of . . . "ideal equipment for a naturalist writer of literary natural history: supreme enthusiasm, tempered with infinite patience and a complete devotion to truth; the broadest possible education; keen eyes, ears and nose; the finest instruments; opportunity for observations; thorough training in laboratory techniques; comprehension of known facts and theories, and the habit of giving full credit for these in the proper place; awareness of what is not known; ability to put oneself in the subject's place; interpretation and integration of observation; a sense of humor; facility in writing; and eternal sense of humbleness and wonder." In this volume Dr. Beebe measures up well to his own rigid standards of good natural history writing.

—CHARLES A. DAMBACH.

# STUDIES OF THE SPIDER PREY OF SEVERAL MUD-DAUBER WASPS[1]

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This study of the spiders provisioned by common mud-dauber wasps occurring in Maryland was initiated in 1937. At that time some material was collected from several nests with the intention of identifying the various species of spiders concerned. Later, 1942, in the course of a survey of the spiders of the state this material was identified and the following trends were observed; one, the predominance of certain species of spiders and two, the occurrence of rare or uncommon species. The predominance of several spiders suggested the possibility of specific food preferences of the different wasps, while the occurrence of uncommon forms indicated accidental collection. The study was begun with these problems as aims.

A survey of available literature showed that although some provisioning studies had been made by early workers, a confusion existed concerning the prey of two wasps. Included in these early studies were those of the Peckhams (1898), Banks (1907) and Rau (1927 and 1928A). In 1928B Rau demonstrated that early workers, including himself, had confused the habits of two species, *Sceliphron caementarium* Drury and *Chalybion coeruleum* Linné, and he indicated their proper relationship. Later (1935A and B) he presented some data on the collecting habits of these two wasps. The data presented here substantiate and supplement Rau's studies.

## THE WASPS

The species treated in this paper are representatives of the superfamily Sphecoidea. Two belong to the family Sphecidae and two to the Trypoxylonidae. All are relatively abundant in the eastern United States. In view of the possibility of confusion of the species concerned short descriptions of the wasps and their habits are given below.

*Sceliphron caementarium* Drury, the yellow-legged or black and yellow mud-dauber, is the most common spider provisioning wasp in the state. It is easily recognized by the rounded lobes of the pronotum, the long, slender petiole and the non-metallic, black and yellow markings. Several color varieties of this species have been described. This wasp is responsible for the so-called "mud-dauber's" nests seen in barns, sheds and other protected situations. In Maryland, it begins to build nests early in June and continues until late September; figure 1 shows a nest characteristic of this species. This wasp deposits its egg on the first spider stored in each cell.

[1]Scientific Article No. A77, Contribution No. 1932 of the Maryland Agricultural Experiment station (Department of Entomology).

*Chalybion coeruleum* Linné, the common blue mud wasp, is characterized by a petiole scarcely as long as the propodeum and a deep metallic blue color. It measures about one inch in length with most specimens being slightly larger than the black and yellow dauber with which it was at one time confused. This confusion resulted from its habit of emptying cells filled by *S. caementarium* and reprovisioning with its own prey. The eggs of this species were found to be placed on the first spider stored. As Rau (1928B) stated that this wasp deposited its egg on the last spider stored, the possibility of a variation in egg laying habit is indicated. After filling and recapping one or more cells of a nest this species daubs pellets of mud on the surface of the nest thereby giving it the characteristic appearance shown in figure 2.

*Trypoxylon politum* Say, the pipe organ wasp, is the largest member of the genus occurring in this region. It measures between one-half and three-quarters of an inch in length and is easily identified by the dark purplish blue wings and white posterior tarsi. The propodeum is smooth dorsally. This wasp builds laminated tubes that are approximately five inches long and usually divided into five cells. A nest may contain a number of these tubes. Figures 3 and 4 show details of a nest constructed by this species.

*Trypoxylon clavatum* Say is slightly less than one-half an inch in length, covered with a white bloom, and possesses nearly clear wings. This species has no common name known to the authors, so for the purposes of this paper it will be known as the guest wasp. Abandoned nests of the black and yellow mud-dauber are utilized by this species. They also are known to provision holes in wood. When provisioning old mud-dauber cells this wasp builds a transverse partition dividing the original cell into two smaller cells as shown in figure 5. Cells which have been recapped by *T. clavatum* may often be recognized by the different color of the new plug. Figure 6 shows this species on an old mud-dauber's nest.

## THE SPIDERS

In this study 4,264 specimens representing ten families, forty-eight genera and eighty-one species were taken from wasp nests. An annotated list of the identified species is given below. In several instances young specimens could not be identified beyond the genus and are not included.

### Family **Mimetidae**

1. **Mimetus notius** Chamberlin—3 females; Charles and Wicomico Counties.
2. **Mimetus puritanus** Chamberlin—2 males and 6 females; Prince Georges and Wicomico Counties.

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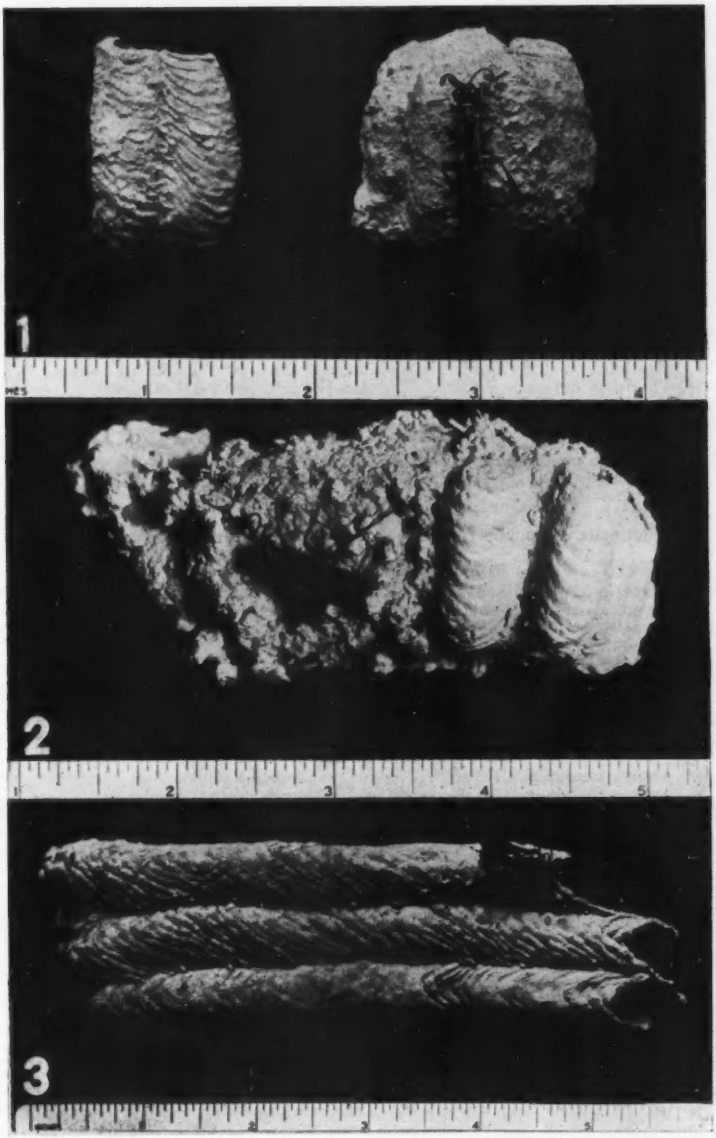
## EXPLANATION OF PLATE I

FIGURE 1. Two nests of *Sceliphron caementarium* Drury, nest on left shows typical laminae before obliteration. 2. *Chalybion coeruleum* Linné on a portion of a nest covered with mud pellets typical of the species. 3. *Trypoxylon politum* Say on a nest typical of the species.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Family **Lycosidae**

3. **Pardosa milvina** Hentz—1 female; Prince Georges County.

Family **Oxyopidae**

4. **Oxyopes salticus** Hentz—1 male and 18 females; Prince Georges and Wicomico Counties.
5. **Oxyopes scalaris** Hentz—62 males and 243 females; Charles, Prince Georges and Wicomico Counties.

Family **Theridiidae**

6. **Asagena americana** Emerton—129 females; Garrett and Prince Georges Counties.
7. **Enoplognatha puritanus** Chamberlin and Ivie—1 male and 193 females; Prince Georges and Garrett Counties.
8. **Latrodectus mactans** Fabricius—No adults, many young identified; Prince Georges, Garrett and Wicomico Counties.
9. **Steatoda borealis** Hentz—1 female, many young identified; Garrett, Prince Georges and Wicomico Counties.
10. **Teutana triangulosa** Walckenaer—1 female and 8 young identified; Prince Georges County.
11. **Theridion australe** Banks—1 male and 44 females; Wicomico County.
12. **Theridion differens** Emerton—1 female; Prince Georges County.
13. **Theridion frondeum** Hentz—63 females; Prince Georges County.
14. **Theridion kentuckyense** Keyserling—1 female; Wicomico County.
15. **Theridion murarium** Emerton—2 females; Garrett and Wicomico Counties.
16. **Theridion tepidariorum** Koch—1 male, 21 females and many young identified; Garrett, Prince Georges and Wicomico Counties.

Family **Linyphiidae**

17. **Frontinella communis** Hentz—1 young identified; Prince Georges County.

Family **Argiopidae**

18. **Acacesia folifera** Marx—4 males, 13 females and many young; Prince Georges and Wicomico Counties.
19. **Acanthepeira stellata** Walckenaer—No adults, many young; Prince Georges and Wicomico Counties.
20. **Aranea displicata** Hentz—4 females; Prince Georges County.
21. **Aranea foliata** Fourcroy—1 female and several young; Garrett and Wicomico Counties.
22. **Aranea miniata** Walckenaer—3 females; Wicomico County.
23. **Aranea nivea** Hentz—42 males, 58 females and several young; Charles, Prince Georges and Wicomico Counties.
24. **Aranea nordmanni** Thorell—1 female; Wicomico County.
25. **Aranea thaddeus** Hentz—1 male and 7 females; Wicomico County.
26. **Argiope aurantia** Lucas—2 males and several young; Prince Georges and Wicomico Counties.
27. **Argiope trifasciata** Forskal—No adults, many young; Garrett and Prince Georges Counties.
28. **Cyclosa conica** Pallas—3 females; Garrett and Prince Georges Counties.
29. **Cyclosa turbinata** Walckenaer—3 females, Wicomico County.
30. **Eustala anastera** Walckenaer—10 males, 118 females and several young; Prince Georges and Wicomico Counties.
31. **Gea heptagon** Hentz—1 male and 22 females; Prince Georges and Wicomico Counties.

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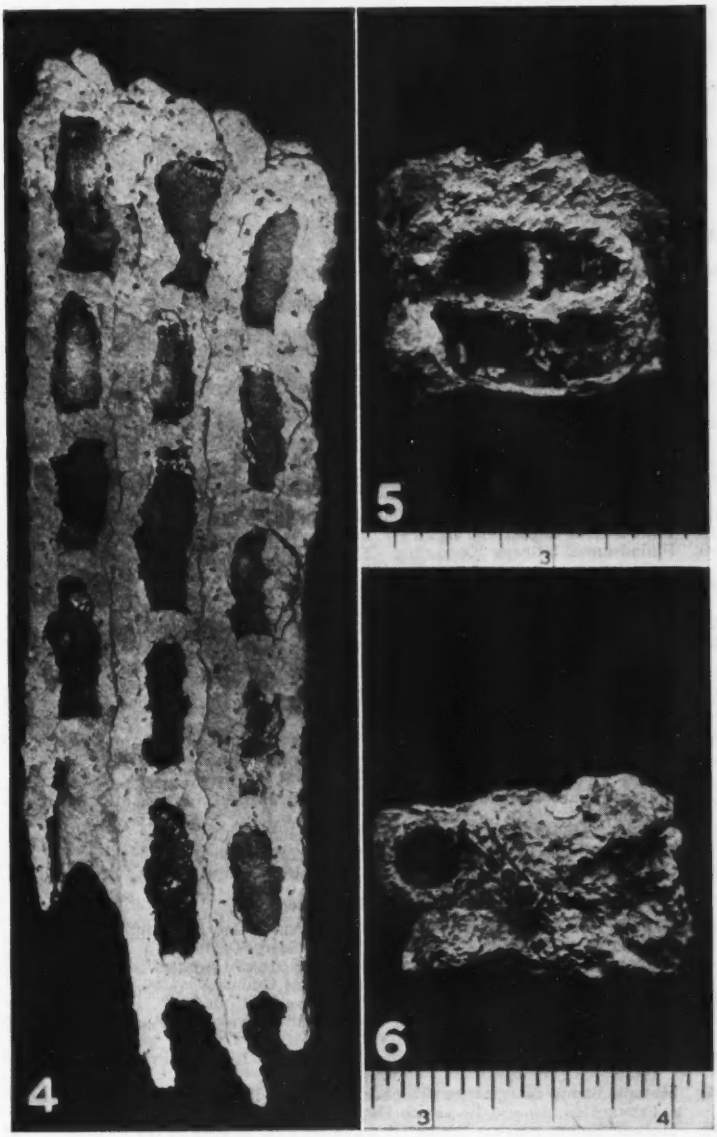
## EXPLANATION OF PLATE II

FIGURE 4. Under side of a nest of *Trypoxylon politum* Say showing details of construction and nest contents. 5. An old nest of *Sceliphron caementarium* Drury showing partitions constructed by *Trypoxylon clavatum* Say. 6. *Trypoxylon clavatum* Say on an old mud-dauber's nest, wasp is facing a cap typical of the species.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32. **Leucage venusta** Walckenaer—3 females; Wicomico County.
33. **Mangora gibberosa** Hentz—15 females; Prince Georges and Wicomico Counties.
34. **Metepeira labyrinthea** Hentz—12 males and 17 females; Charles, Prince Georges and Wicomico Counties.
35. **Micrathena reduviana** Walckenaer—1 young; Prince Georges County.
36. **Micrathena sagittata** Walckenaer—7 young; Prince Georges and Wicomico Counties.
37. **Neoscona arabesca** Walckenaer—10 females; Garrett, Prince Georges and Wicomico Counties.
38. **Neoscona minima** Cambridge—2 males, 25 females and several young; Prince Georges and Wicomico Counties.
39. **Pachygnatha tristriata** Koch—1 female; Prince Georges County.
40. **Verrucosa arenata** Walckenaer—3 young; Prince Georges and Wicomico Counties.
41. **Wixia ectypa** Walckenaer—3 young; Garrett and Prince Georges Counties.

Family **Thomisidae**

42. **Coriarachne versicolor** Keyserling—6 females; Prince Georges County.
43. **Misumena calycina** Linnaeus—No adults, many young; Prince Georges and Wicomico Counties.
44. **Misumenoides aleatorius** Hentz—5 females and several young; Prince Georges and Wicomico Counties.
45. **Misumenops asperatus** Hentz—18 females; Prince Georges and Wicomico Counties.
46. **Misumenops celer** Hentz—1 female; Wicomico County.
47. **Misumenops oblongus** Keyserling—10 females; Charles, Prince Georges and Wicomico Counties.
48. **Philodromus imbecillus** Keyserling—1 female; Prince Georges County.
49. **Philodromus keyserlingi** Marx—7 females; Wicomico County.
50. **Philodromus laticeps** Keyserling—21 females; Prince Georges and Wicomico Counties.
51. **Philodromus pernix** Blackwall—36 females; Charles, Prince Georges and Wicomico Counties.
52. **Philodromus rufus** Walckenaer—12 females; Prince Georges County.
53. **Tmarus angulatus** Walckenaer—4 females; Prince Georges and Wicomico Counties.
54. **Xysticus funestus** Keyserling—5 males and 7 females; Wicomico County.
55. **Xysticus punctatus** Keyserling—1 male and 11 females; Prince Georges and Wicomico Counties.
56. **Xysticus triguttatus** Keyserling—3 females, Prince Georges and Wicomico Counties.

Family **Clubionidae**

57. **Chiracanthium inclusum** Hentz—7 females; Prince Georges and Wicomico Counties.
58. **Clubiona minuta** Emerton—1 male; Prince Georges County.
59. **Clubiona obesa** Hentz—1 female; Prince Georges County.
60. **Clubiona pallens** Hentz—1 male and 4 females; Prince Georges County.

Family **Salticidae**

61. **Habronattus coronatus** Hentz—1 female; Prince Georges County.
62. **Hentzia mitrata** Hentz—2 females; Prince Georges County.
63. **Hentzia palmarum** Hentz—1 male; Prince Georges County.
64. **Icius elegans** Hentz—1 male; Prince Georges County.
65. **Maevia vittata** Hentz—1 young; Prince Georges County.
66. **Marpissa undata** DeGeer—1 male and 3 females; Prince Georges and Wicomico Counties.
67. **Metaphidippus capitatus** Peckham—1 male and 5 females; Prince Georges and Wicomico Counties.
68. **Metaphidippus marginatus** Walckenaer—19 males and 32 females; Charles, Prince Georges and Wicomico Counties.
69. **Metaphidippus ornatus** Banks—4 males and 13 females; Prince Georges and Wicomico Counties.

70. **Parnaenus chrysis** Walckenaer—3 males and 3 females; Prince Georges County.
71. **Phidippus audax** Hentz—2 females; Wicomico County.
72. **Phidippus insolens** Hentz—1 female; Prince Georges County.
73. **Phidippus mystaceus** Hentz—3 males and 2 females; Wicomico County.
74. **Phidippus putnami** Peckham—3 males and 13 females; Prince Georges and Wicomico Counties.
75. **Sassacus papenhoei** Peckham—1 female; Prince Georges County.
76. **Thiodina sylvana** Hentz—2 females; Charles and Prince Georges Counties.
77. **Zygoballus sexpunctatus** Hentz—6 males and 4 females; Prince Georges County.

Family **Anyphaenidae**

78. **Anyphaena fragilis** Banks—4 females; Prince Georges and Wicomico Counties.
79. **Anyphaena fraterna** Banks—1 male; Prince Georges County.
80. **Anyphaena pectorosa** Koch—30 males and 44 females; Prince Georges and Wicomico Counties.
81. **Aysha gracilis** Hentz—5 females; Prince Georges and Wicomico Counties.

From the list given it is evident that spider collections may be greatly enriched by material from wasp nests. Fine series of rare and uncommon species as well as many specimens of common spiders may be taken by this method. The appearance of such uncommon species as *Theridion australe* Banks, *Aranea nivea* Hentz, *Clubiona minuta* Emerton, *Philodromus imbecillus* Keyserling and *Anyphaena fragilis* Banks substantiates this statement. It will also be noted that the female of *Phidippus putnami* Peckham is listed. This is the first record of this sex of the species. Another interesting record is the existence of a red-spotted form of *Aranea nivea* Hentz.

## CORRELATION STUDIES

In correlating the different species of wasps with the spiders collected by each, several factors were considered; first, an apparent preference of each for one or more family, genus or species of spider; second, the occasional deviation of a wasp from this pattern; and last, the seasonal shift from one preferred group to another. As Table I includes data applicable only to the spider families, this discussion will be concerned principally with information concerning the genera and species.

Apparent food preferences of the different wasp species and the occasional deviations from these preferences are, according to Rau (1935B), due to the environs in which they hunt. It was his conclusion that the blue mud-dauber searched for spiders near buildings and under boards while the yellow-legged dauber hunted among foliage and flowers. An attempt was made here to determine whether the spiders collected are dependent upon the environment visited by the wasps or upon a preference for certain groups of spiders.

### **Sceliphron caementarium** Drury

Of the 2,021 specimens taken from the nests and cells of the yellow-legged mud-dauber there were 1,126 Argiopidae, 325 Thomisidae, 204 Salticidae, 191 Oxyopidae, 106 Anyphaenidae, 42 Clubionidae, 12 Mimetidae, 11 Theridiidae and 4 Lycosidae.

TABLE I

SUMMARY OF MATERIAL COLLECTED[2]

| FAMILY | SEASON | *S.caementarium* | *C. coeruleum* | *T. politum* | *T. clavatum* | Misc. |
|---|---|---|---|---|---|---|
| Mimetidae | 6/15–7/15 | 7 | | | | |
| | 7/15–8/15 | 5 | | | | 6 |
| | 8/15–9/15 | | | | | |
| Lycosidae | 6/15–7/15 | 1 | | | | |
| | 7/15–8/15 | 2 | | | 2 | |
| | 8/15–9/15 | 1 | | | 2 | |
| Oxyopidae | 6/15–7/15 | 107 | 15 | | | |
| | 7/15–8/15 | 80 | | | 5 | 122 |
| | 8/15–9/15 | 4 | | | 1 | |
| Theridiidae | 6/15–7/15 | | 110 | 13 | | |
| | 7/15–8/15 | 11 | 398 | | 7 | 179 |
| | 8/15–9/15 | | 120 | | | |
| Linyphiidae | 6/15–7/15 | | 1 | | | |
| | 7/15–8/15 | | | | | |
| | 8/15–9/15 | | | | | |
| Argiopidae | 6/15–7/15 | 506 | 74 | 8 | | |
| | 7/15–8/15 | 426 | 165 | 384 | 29 | 211 |
| | 8/15–9/15 | 194 | 10 | 34 | 1 | |
| Thomisidae | 6/15–7/15 | 62 | 16 | | 23 | |
| | 7/15–8/15 | 113 | 1 | | 17 | 31 |
| | 8/15–9/15 | 150 | | | 21 | |
| Clubionidae | 6/15–7/15 | 2 | | | | |
| | 7/15–8/15 | 9 | | | | |
| | 8/15–9/15 | 31 | | | | |
| Salticidae | 6/15–7/15 | 22 | 13 | | | |
| | 7/15–8/15 | 151 | 2 | | 202 | 17 |
| | 8/15–9/15 | 31 | | | | |
| Anyphaenidae | 6/15–7/15 | 4 | 1 | | 1 | |
| | 7/15–8/15 | 83 | | | | |
| | 8/15–9/15 | 19 | | | | |
| Total | | 2,021 | 927 | 439 | 311 | 566 |
| Grand Total | | 4,264 | | | | |

[2]Early general collections account for miscellaneous group while later material was taken from nests and cells of positively identified species.

In the Argiopidae there were 527 young *Neoscona*, 126 young *Aranea*, 126 *A. trifasciata*, 100 *A. foliata*, 99 *A. nivea*, 69 *M. labyrinthea*, 19 *E. anastera* and 5 *M. gibberosa*. It is interesting to note that the relatively uncommon *A. nivea* appears more frequently than such common species as *M. labyrinthea*, *E. anastera* and *M. gibberosa*.

Except for the collection of 44 specimens of the crab spider *P. pernix* which occurs commonly around human habitation, all of the 325 Thomisidae collected by this wasp were foliage or flower-loving forms; 152 being young Misumeninae.

Of the 204 foliage and flower-loving Salticidae collected by *S. caementarium* 127 were young *Phidippus*. No other genus or species was taken in quantity.

All species of the other families collected were foliage-loving except for the four ground inhabiting Lycosidae.

Several seasonal shifts in food habits were noted. The number of Argiopidae, Anyphaenidae and Oxyopidae decreased as the season advanced while the reverse was true for the Thomisidae and Clubionidae. This change in collecting habits caused a preponderance of Argiopidae over all other families in the early season with equal proportions of Argiopidae and other families in mid-season, while in late season less Argiopidae were collected than the other combined families.

From data collected on the provisioning habits of this wasp it appears that the spiders collected are dependent upon several factors: one, the hunting environs of the wasp; two, the prevalence of certain species of spiders; three, the size of the prey and four, the time of season in which the collection is made. The fact that an overwhelming majority of the spiders found in cells provisioned by *S. caementarium* were foliage and flower inhabiting forms definitely establishes these environs as its hunting site. As all of the species collected in numbers, except for one, *Aranea nivea* Hentz, are common forms in this area it is apparent that prevalance of a spider is an important factor governing the provisioning habit. Although the occurrence of ninety-nine specimens of *A. nivea* appears to refute the latter hypothesis it is believed that this obscure species will prove to be more common than its rare occurrence in arachnid collections indicates. The size and season factors limiting the provisions of the yellow-legged dauber are closely related. A total of 932 young spiders identified only to the genus supplemented by numerous identified young of *A. trifasciata* and *A. foliata* indicates a strong tendency toward the collection of smaller more easily handled prey. This information, combined with the knowledge that many of the larger Argiopidae mature in late summer, can be used to explain the seasonal shift in food habits.

**Chalybion coeruleum** Linné

Of the 927 spiders collected from cells of the blue mud-dauber there were 628 Theridiidae, 249 Argiopidae, 17 Thomisidae, 15 Oxyopidae, 15 Salticidae and one each of the families Mimetidae, Linyphiidae and Anyphaenidae.

The Theridiidae which occurred most frequently were *L. mactans* with 235 specimens, *A. americana*, 130; *E. puritanus*, 88; *T. tepidariorum*, 62; *T. frondeum*, 57; *S. borealis*, 26; and *T. australe*, 17. The occur-

rence of *T. frondeum* and *T. australe*, foliage-loving spiders, is interesting when compared with the collection of *T. tepidariorum*, the common domestic spider.

In the Argiopidae there were 60 specimens of young *Neoscona*, 84 young *Aranea*, 30 *A. foliata* and 22 *G. heptagon*. Here again it is interesting to note that *G. heptagon*, a spider found on foliage, occurred often in the cells of this wasp. No attempt was made to identify the immature *Neoscona* and *Aranea* beyond the genus as such identifications would have been questionable.

Except for six young Misumeninae, which in all probability would be found occasionally around human habitations, the Thomisidae collected are forms found in and on houses and barns.

Of the 15 Oxyopidae collected 14 were *O. scalaris*, a species often reported from fences, barns or houses.

In the Salticidae, 13 of the 15 specimens collected were *M. marginatus*, a foliage-inhabiting form.

A shift in food habits occurred from early season when nearly equal proportions of Theridiidae to other species were taken, to late season when there was a great preponderance of Theridiidae.

Factors governing the provisioning habits of the blue mud-dauber are the environs in which it hunts, the prevalance of certain species of spiders, the size of prey and the season in which the collection is made. The collection of large numbers of spiders found near the ground and around human habitation establishes the usual hunting area of this wasp. In several instances, however, it was observed provisioning and capping cells found to contain only foliage-loving spiders. These observations of a direct reversal in habit are substantiated by the occurrence in cells of *C. coeruleum* of 139 foliage inhabiting spiders, 15 per cent of the total collected, a figure too large to attribute to accidental collection. The data indicate that this wasp occasionally changes its hunting locale. Since the majority of specimens taken were common species, the prevalence of a spider must be considered a limiting provisioning factor with this wasp as it was for the yellow-legged dauber. Season and size of prey account for the limiting of late summer collections to the small or medium sized Theridiidae.

**Trypoxylon politum** Say

The pipe organ wasp is particularly limited in food habits. Of the 439 specimens collected, 283 were *Neoscona*. The only other predominating orb weaver was *E. anastera*, which occurred 104 times. Except for 31 young *Aranea* all other collections of orb weavers were single specimens. The few Theridiidae taken can easily be attributed to accidental collection. As the pipe organ builder does most of its nest building during mid-season no data on seasonal shift of food habits could be obtained.

As 64.4 per cent of the collections of this wasp were specimens of the genus *Neoscona* and 23.6 per cent specimens of *E. anastera* it is difficult to analyze the data collected in regard to factors limiting the provisioning habit. However, as these forms are extremely abundant on foliage in Maryland, two facts are evident, one, that the wasp visits foliage while hunting its prey and two, that prevalence of a

spider is an important factor. The almost complete absence of other common orb weaving spiders from the collections of this wasp seems to indicate a preference for certain spiders. Size of prey apparently is not important as cells opened early in the building season contained many small spiders while those opened late held a few large specimens.

**Trypoxylon clavatum** Say

Of the 311 specimens taken from cells of the guest wasp there were 202 Salticidae, 61 Thomisidae and 30 Argiopidae. The remaining 18 specimens were distributed among the families Lycosidae, Oxyopidae, Theridiidae and Anyphaenidae. As this is a small wasp there was a preponderance of young spiders and small species in its cells. There were 164 young *Phidippus* (Salticidae), 57 young *Misumeninae* (Thomisidae) and 16 young *Aranea* (Argiopidae). This wasp is active only in mid-season so no indication of a shift in food habits could be determined.

Collecting environs and size of the prey are the major factors limiting the provisioning habits of the guest wasp. Its flower visiting habit is established by the predominance of Salticidae and Thomisidae both of which are common on flowering plants in open areas. As only sixteen small species could be identified from material found in cells of *T. clavatum*, size of prey must be considered important.

SUMMARY

1. Rare and uncommon spiders as well as common species may be found among the provisions of mud-dauber wasps.

2. Prey collected by *S. caementarium* Drury is limited by the hunting environment of the wasp, size and prevalence of the spiders, and season.

3. Prey collected by *C. coeruleum* Linné is affected by the same factors as those of *S. caementarium* although this species appears to change its hunting area occasionally.

4. *T. politum* Say collects common spiders among foliage apparently preferring species of the genera *Neoscona* and *Eustala*.

5. *T. clavatum* Say collects small or immature spiders that are common on flowering plants in open areas.

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# NEW SPECIES OF CRANE-FLIES FROM SOUTH AMERICA. PART XII[1]

## (Diptera: Tipulidae)

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At this time I am considering a number of species, chiefly from Peru, where they were collected by Messrs. Pedro Paprzycki, J. Adger Smyth, and Felix Woytkowski. Other interesting forms are from Brazil, taken by Messrs. Thomaz Borgmeier, Lèrio Gomes, Fritz Plaumann and Michael Witte, and from Bolivia, taken by Dr. William M. Mann while a member of the Mulford Biological Expedition 1921–1922. I am greatly indebted to all of these entomologists for the privilege of studying these important additions to the known fauna of Tropical America. Except where stated to the contrary in the text, the types are preserved in my private collection of World Tipulidae.

### Genus **Holorusia** Loew

**Holorusia (Holorusia) vulpes** sp. n.

Size large (wing, female, over 26 mm.); general coloration of thorax fulvous, the praescutum with a delicate brown median vitta; flagellar segments bicolored; halteres elongate; legs yellow, the extreme tips of tibiae and the outer tarsal segments infuscated; wings with a very strong fulvous ground, the centers of various cells, particularly *M*, with conspicuous paler lacunae; a very restricted dark pattern, including a prearcular costal darkening and an unusually small spot at origin of *Rs;* a paler cloud at near midlength of cell *M* adjoining vein *Cu; Rs* long, about two and one-half times *m-cu;* inner end of cell *1st* $M_2$ strongly arcuated; abdominal tergites fulvous, the basal ones darker except on their lateral portions.

*Female.*—Length, about 26 mm.; wing, 28 mm.

Frontal prolongation of head deep reddish brown, with a narrow, more darkened lateral line; nasus elongate, simple; palpi black, relatively short and stout, the terminal segment only about one-third longer than the penultimate. Antennae with scape and pedicel obscure yellow; flagellar segments weakly bicolored, brown, their tips narrowly yellow, involving about the distal third or fourth of segment; flagellar segments nearly cylindrical. Head rich fulvous brown; area surrounding antennal bases corrugated; anterior vertex relatively wide, approximately three times the diameter of scape.

Pronotum testaceous brown. Mesonotum more fulvous, the praescutum virtually unpatterned except for a delicate darkened

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[1]Contribution from the Entomological Laboratory, Massachusetts State College.

The preceding part under this general title was published in the Annals of the Entomological Society of America, 37: 298–322, 1944.

vitta on about the posterior four-fifths; posterior lateral portions of praescutum more infuscated; scutum chiefly infuscated, paling to yellow posteriorly; scutellum pale brown, a little more darkened at base; mediotergite obscure yellow or brownish yellow, the posterior third more grayish pruinose; pleurotergite yellow. Pleura obscure yellow, dorsopleural membrane more fulvous. Halteres elongate, brown, the apex of knob more yellowed. Legs with coxae and trochanters yellowish testaceous; remainder of legs uniform yellow, the tips of tibiae narrowly infuscated; outer tarsal segments darkened. Wings with an unusually strong fulvous ground, with conspicuous paler centers to some of the cells, the one in cell *M* largest and most evident, forming an elongate triangle; other similar pale areas in centers of cells of *2nd* $M_2$, $M_3$ and $M_4$, the last largest; linear pale streaks in centers of both anal cells; very indistinct similar lines in cell *R* immediately before origin of *Rs* and near outer portion of cell *Cu*, immediately adjoining the vein; prearcular costal field, including *h* and a small postarcular cloud dark brown; a similar tiny but conspicuous dark brown seam close to origin of *Rs;* a larger but more vague brown cloud in cell *M* near midlength, lying close to vein *Cu;* obliterative areas before stigma and across cord conspicuous; veins deep yellow. Veins unusually glabrous, those beyond cord and caudad of vein $R_1$ entirely without trichia. Venation: *Rs* long, about two and one-half times *m-cu;* distal section of $R_{4+5}$ strongly sinuous on basal half; cell *1st* $M_2$ elongate, pointed at outer end, very strongly arcuated at inner end which lies far before level of either $R_3$ or $R_5$; petiole of cell $M_1$ a little more than one-half *m*.

Abdominal tergites fulvous, the basal segments slightly more infuscated; lateral borders of the more proximal tergites and all of the sternites more yellow. Ovipositor with cerci appearing as flattened vertical blades, their tips narrowly obtuse.

*Habitat.*—Brazil (Paranà). *Holotype*, ♀, Rio Negro, altitude about 600 meters, March 15, 1940 (Father Michael Witte, S. Franciscanos); through Borgmeier.

The most similar regional species is *Holorusia* (*Holorusia*) *parvimacula* sp. n., which differs conspicuously in the ground color and pattern of the wings, coloration of the body, and in the much shorter antennae.

**Holorusia (Holorusia) parvimacula** sp. n.

Size relatively large (wing, female, 24 mm.); mesonotal praescutum pale brown, with four scarcely differentiated brown stripes; antennal flagellum bicolored, the bases of the segments brown; mesonotal pleurotergite with its dorsal border dark brown, the color continued caudad onto the lateral borders of the abdominal tergites; legs obscure yellow, the outer segments slightly darker; wings with a strong yellowish brown tinge, the costal border on proximal half darker; central area of wing on proximal portion more yellowish white; three small, dark brown areas on disk, the largest at midlength of vein *Cu* in cell *M;* veins pale; cell $R_3$ strongly constricted at near midlength.

*Female.*—Length, about 23 mm.; wing, 24 mm.

Frontal prolongation of head brown; nasus distinct, simple; palpi dark brown, the incisures a little whitened; terminal segment beyond the base paling to brownish yellow. Antennae with scape brown, pedicel yellow; flagellar segments bicolored, with approximately the basal half of each brown, the remainder yellow, the bicolorous nature involving all but the outer two segments; flagellar segments subcylindrical or with the basal enlargements barely indicated. Head brown.

Pronotum dark brown. Mesonotal praescutum pale brown, with four scarcely differentiated brown stripes that are very narrowly and insensibly margined by darker; scutum similar in color, the centers of the lobes a trifle darkened; scutellum testaceous brown, the parascutella pale gray; mediotergite gray pruinose; pleurotergite obscure yellow, the dorsal border conspicuously dark brown, the marking continued behind onto the lateral borders of the abdominal tergites. Pleura chiefly obscure testaceous yellow; dorsopleural region a trifle darker. Halteres dark brown, the base of stem paler. Legs with coxae and trochanters brownish yellow; remainder of legs passing through obscure yellow to brownish yellow. Wings with a strong yellowish brown tinge, the costal region on proximal half somewhat more darkened; central portion of wing on proximal half paler, more yellowish white, involving the posterior prearcular field, bases of cells *Cu* and *1st A*, and extensive outer portions of cells *R* and *M;* dark brown spots at arculus in base of cell *M*, at origin of *Rs*, and near midlength of cell *M* adjoining vein *Cu* all unusually small; stigma not or scarcely differentiated from the ground, a trifle darker on its outer portion near costa; veins pale, poorly indicated. Venation: *Rs* long, nearly twice the long *m-cu;* veins $R_3$ and $R_{4+5}$ unusually sinuous, greatly constricting cell $R_3$ at near midlength; petiole of cell $M_1$ about one-half *m; m-cu* on $M_{3+4}$ shortly before fork.

Abdominal tergites obscure brownish yellow to pale brown medially, the lateral borders darker brown, as above described, on the outer segments more uniformly brown. Ovipositor with the cerci compressed-flattened, relatively broad.

*Habitat.*—Brazil (Rio de Janeiro). *Holotype*, ♀, Manguinho, D. F., October, 1940 (Lèrio Gomes).

The present fly is most similar to species such as *Holorusia* (*Holorusia*) *vulpes* sp. n., as discussed above. Among the described species, it appears to be closest to *H.* (*H.*) *laevis* Alexander, but is quite different.

## Genus **Tipula** Linnaeus

### **Tipula (Microtipula) plaumannina** sp. n.

Allied to *gutticellula;* antennae (male) about one-half the length of wing; flagellar segments weakly tricolored; $M_{3+4}$ elongate, subequal to basal section of $M_{1+2}$; male hypopygium with the apex of inner dististyle lacking spinous points.

*Male.*—Length, about 11.5–12 mm.; wing, 12–12.5 mm.; antenna about 6.5 mm.

*Female.*—Length, about 12–14 mm.; wing, 11.5–13 mm.

Frontal prolongation of head pale brown; nasus short and stout;

palpi pale testaceous brown. Antennae (male) elongate; basal three segments yellow; succeeding segments weakly tricolored, the basal enlargement black, the extreme tip yellow, the intermediate portion of each segment brown; on the outermost segments this pattern is less evident; basal enlargements relatively conspicuous; longest verticils shorter than the segments. Head brown, sparsely pruinose; no vertical tubercle; anterior vertex about three times the diameter of scape.

Pronotum and mesonotum reddish brown, without distinct pattern; praescutal interspaces with conspicuous erect setae. Pleura obscure brownish yellow. Halteres with stem obscure yellow, knob brown. Legs with coxae and trochanters yellow; femora obscure yellow; tibiae obscure yellow, the tips very narrowly infuscated; tarsi brownish black, the basitarsi restrictedly brightened at proximal end; claws toothed. Wings patterned as in *gutticellula*. Venation: *Rs* shorter and more strongly arcuated; cell $M_1$ shorter and broader; $M_{3+4}$ elongate, subequal to the basal section of $M_{1+2}$.

Abdomen obscure yellowish brown, the tergites with a conspicuous black longitudinal stripe on extreme lateral portions, continuous on basal segments, broken on the basal rings of outer segments; segments six to eight, inclusive, black; hypopygium yellow. Ovipositor with the cerci very short and blunt, hairy, as common in the subgenus. Male hypopygium with the apical lobes of tergite relatively stout, the notch correspondingly short and shallow; each lobe tipped with abundant black setae. Inner dististyle without apical spinous points. Notch of ninth sternite bearing a profoundly bilobed appendage, each lobe densely tufted with long yellow setae, the longest not much shorter than either lobe itself.

*Habitat.*—Brazil (Santa Catharina). *Holotype*, ♂, Nova Teutonia, November 18, 1936 (Fritz Plaumann). *Allotopotype*, ♀, with type. *Paratopotypes*, 1♂, October 30, 1935; 1♀, February 12, 1937.

I am privileged to name this species after the collector, Mr. Fritz Plaumann, who has added vastly to our knowledge of the insect fauna of extreme southern Santa Catharina. The best accounts of the nature of the country in the vicinity of Nova Teutonia have been given by Plaumann himself.[2] *Tipula* (*Microtipula*) *plaumannina* has the wing pattern much as in *T.* (*M.*) *gutticellula* Alexander and *T.* (*M.*) *tijucensis* Alexander, and all three species are closely inter-allied. The present fly differs from *tijucensis* especially in the details of structure of the male hypopygium, particularly of the tergite and dististyles. *Tipula gutticellula* is still known only from the female sex but shows sufficient differences in venation and coloration to warrant the expectation that the male sex, when discovered, will show further differences from the two species above discussed.

**Tipula (Microtipula) mulfordi** sp. n.

General coloration yellow; antennae (male) long, weakly bicolored; basal enlargements of the segments small; wings with a weak brownish

[2]Im Urwald. Entomologischen Rundschau, 54: 120–125 (1936); 213–216, 293–298, 320–321 (1937). Ueber das Sammeln in brasilianischen Urwald. Koleopterologische Rundschau, 23: 236–243 (1937); 24: 7–13 (1938).

tinge, the prearcular, costal and outer radial fields darker brown; restricted brown seams on cord, outer end of cell *1st* $M_2$ and as marginal clouds on outer medial and cubital veins; male hypopygium with the caudal margin of tergite trilobed, the lateral lobes long and slender, the median one broad, tipped with about twenty spinous setae; eighth sternite moderately sheathing, at its apex with a small median lobe.

*Male.*—Length, about 11 mm.; wing, 11.5 mm.; antenna, about 6 mm.

Allied to *tenuilobata*, differing especially in the details of structure of the male hypopygium. Frontal prolongation of head obscure yellow; nasus relatively short; basal segments of palpi pale, the outer segments broken. Antennae (male) long, exceeding one-half the length of wing; basal segments yellow, the outer ones weakly bicolored, yellow, with the basal enlargements a trifle darker; outer segments more uniformly darkened; basal enlargements of segments small, the remainder nearly cylindrical; verticils shorter than the segments. Head pale brown; no vertical tubercle.

Mesonotum chiefly yellow, the praescutum and scutum without distinct pattern; praescutal setae sparse and delicate. Pleura pale yellow. Halteres with stem yellow, knob weakly darkened. Legs with coxae and trochanters yellow; femora and tibiae yellow, tarsi passing into brown. Wings with a weak brownish tinge, the prearcular, costal and outer radial fields more strongly darkened; restricted brown seams on cord, outer end of cell *1st* $M_2$, fork of $M_{1+2}$, and as small marginal clouds on veins $M_1$ to $Cu_1$, inclusive; veins pale brown, somewhat darker in the patterned areas. Venation: Compared with *tenuilobata*, cell $R_1$ slightly narrower; vein $R_{1+2}$ more oblique; cells $M_1$, *1st* $M_2$ and *2nd* $A$ narrower.

Abdomen yellow, the tergites narrowly darkened laterally; sternites yellow; a narrow, dark brown, subterminal ring; hypopygium yellow. Male hypopygium generally as in *tenuilobata*, differing especially in the structure of the tergite and inner dististyle. Ninth tergite with the lateral lobes long and slender, each tipped with about ten long setae; median lobe shorter, broad, a little expanded outwardly, its caudal margin gently concave and provided with about a score of strong spinous setae. In *tenuilobata* the median lobe is narrow, not emarginate at apex, the setae fewer and more elongate. Appendage of ninth sternite much as in *tenuilobata*, appearing as two slender straight arms, divergent, provided with long appressed setae. Eighth sternite moderately projecting, the caudal border produced into a small median lobe, the tip narrowly obtuse, in *tenuilobata* more obtusely rounded.

*Habitat.*—Bolivia (Beni). *Holotype*, ♂, Cavinas, January, 1922 (M. W. Mann); Mulford Biological Expedition 1921–22; U. S. National Museum.

The nearest described relative of the present fly is *Tipula* (*Microtipula*) *tenuilobata* Alexander, of Amazonian Ecuador, which differs in the somewhat shorter antennae, broader wings, and especially the details of structure of the male hypopygium, as compared above.

**Tipula (Microtipula) ortoni** sp. n.

General coloration of mesonotum reddish brown, the praescutum with four poorly indicated stripes; antennae (male) relatively short, flagellum black; pleura uniformly pale yellow; halteres infuscated; wings with a weak brownish tinge, the cells beyond cord, especially the wing tip, more strongly darkened; stigma dark brown; cell *2nd A* narrow; male hypopygium with the basistyle produced caudad into a compressed yellow blade; inner dististyle large, bispinous; appendage of ninth sternite long and narrow, pale, at apex split into two finger-like lobes.

*Male.*—Length, about 11 mm.; wing, 12 mm.; antenna, about 4.2 mm.

Frontal prolongation of head obscure yellow, the dorsal surface with conspicuous black setae; nasus short and stout, tufted with black setae; palpi obscure yellow, elongate. Antennae (male) relatively short for a member of the subgenus; scape and pedicel yellow, flagellum black, the first segment obscure yellow, passing into brown; flagellar segments elongate, rather strongly incised; verticils shorter than the segments. Head grayish brown, the occiput slightly brightened; anterior vertex wide.

Pronotum obscure yellow. Mesonotal praescutum reddish brown, its cephalic portion more grayish; vague indications of four stripes that are poorly differentiated from the ground; posterior sclerites of notum dark reddish brown, the lateral portions of mediotergite still darker. Pleura and pleurotergite pale yellow. Halteres infuscated. Legs with coxae and trochanters pale yellow; femora pale brown, the tips weakly darkened; tibiae brown; tarsi brownish black. Wings with a weak brown tinge, the cells beyond cord, especially the wing tip, more strongly darkened; costal border, especially cell *Sc*, a trifle darker than the ground; stigma oval, dark brown; a restricted to scarcely evident darkened cloud on anterior cord; veins dark brown. Venation: *Rs* arcuated, about one-third longer than *m-cu; $R_{1+2}$* preserved; petiole of cell *$M_1$* longer than *m;* cell *2nd A* narrow.

Abdominal tergites reddish brown, the segments variegated with yellow areas on their glabrous basal rings, the second tergite further brightened at midlength; outer segments more uniformly dark brown; sternites yellow, the outer segments darkened. Male hypopygium with the tergite elongate, its caudal margin broadly and shallowly emarginate, the lateral lobes obtuse; from ventral surface of caudal margin lie two closely approximated oval black lobes that are provided with short black spines. What is interpreted as representing the proctiger appears as two strongly compressed yellow blades beneath the tergite. Basistyle produced into a long compressed yellow blade; mesal face of style near base with a blackened corrugated lobe, as is frequent in the subgenus. Outer dististyle appearing as a very small lobule provided with only five or six long setae. Inner dististyle a strongly bifid structure, produced into two blackened spines, the more ventral one longer, stouter and more acute at apex, the dorsal arm slender, blackened. Appendage of ninth sternite long, pale, at apex split into two fingerlike lobes, the entire appendage with abundant

pale yellow setoid projections. Eighth sternite sheathing, its apex broadly obtuse, with a group of relatively long, conspicuous setae. What appears to represent the aedeagus is a long slender rod, its lateral portions slightly produced into a flange, the margins microscopically fimbriate.

*Habitat*—Bolivia (Beni). *Holotype*, ♂, Cavinas, February, 1922 (W. M. Mann); Mulford Biological Expedition 1921–22; U. S. National Museum.

Named for the noted explorer, James Orton, who died in 1877 from exposure after investigating the Great Beni River. He is buried on Esteves Island in Lake Titicaca. The closest described ally of the present fly is *Tipula* (*Microtipula*) *didactyla* Alexander, of Peru, which has the inner dististyle of the male hypopygium of somewhat this same peculiar conformation. In all other details of coloration and hypopygial structure, the two flies are amply distinct.

**Tipula (Eumicrotipula) paranensis** sp. n.

Belongs to the *glaphyroptera* group; allied to *profuga;* size large (wing, male, over 20 mm.); antennae short, basal flagellar segments bicolored; mesonotal praescutum with four entire dark brown stripes, the cephalic portion with an additional median capillary vitta dividing the ground line; posterior sclerites of notum conspicuously patterned; femora brownish yellow, tips conspicuously blackened; wings pale cream yellow, conspicuously clouded with dark brown and paler brown areas; $R_{1+2}$ entire; cell *1st* $M_2$ large; male hypopygium with the caudal margin of ninth tergite with three acute points; eighth sternite with a deeply bilobed appendage.

*Male.*—Length, about 19 mm.; wing, 22.5 mm.; antenna, about 2.8 mm.

Frontal prolongation of head light brown; nasus elongate; palpi with first segment black, second brown; outer segments broken. Antennae short; scape brownish yellow; pedicel yellow; first flagellar segment yellow, the succeeding ones bicolored, their basal portion brown, the distal two-thirds yellow, on outer segments uniformly infuscated; basal portion of segments enlarged but not forming a conspicuous swelling; verticils long and conspicuous. Head light brownish yellow, with a darker brown central vitta.

Pronotum with the ground obscure yellow, conspicuously patterned with dark brown. Mesonotal praescutum obscure yellow, with four entire dark brown stripes that greatly restrict the ground; intermediate stripes confluent behind, divided by a brownish yellow line on more than the anterior half, this latter further split by a capillary black vitta; scutum yellowish gray, each lobe with two conspicuous dark brown areas; scutellum light brown, the center brownish black, parascutella brown; mediotergite conspicuously patterned, the cephalic half infuscated, sending a central point backward to the caudal margin, this area bordered laterally and behind by buffy yellow, the posterior border of sclerite with a pair of circular brown spots; pleurotergite yellow, the posterior half of katapleurotergite conspicuously brownish black. Halteres with stem brownish yellow, knob weakly infuscated basally, the

apices obscure yellow. Legs with the coxae and trochanters obscure yellow; femora brownish yellow, the tips conspicuously blackened, the amount subequal on all legs, involving about the distal tenth of segment, preceded by a narrow, vaguely indicated, clearer yellow ring; remainder of legs brown, the outer tarsal segments darker; claws small, simple. Wings with the ground color pale cream yellow, cell *C* more brownish yellow, interspaces of cell *Sc* clear yellow; a heavy and very conspicuous dark brown and paler brown clouded pattern; most of prearcular field darkened; a series of four subcostal dark brown areas, the first large, extending from *h* across bases of cells *R* and *M* into cell *Cu;* second and third areas not involving cell *C*, behind almost crossing cell *R* and more or less interconnected by a central darkening in the latter cell; stigma pale brown, not differentiated from the extensive cloudings elsewhere on wing; the paler brown areas much exceed the yellow ground except in the subbasal portions of cells *R* and *M;* in cell *1st A* the dark and yellow patterns become very irregular; yellow post-stigmal mark very restricted, scarcely passing cell $R_2$ behind; cells $M_1$ to $M_4$ with central yellow marginal areas, subtended by darkenings at ends of the veins; ground areas in cells *R* and *M* paler and more conspicuous; veins brown, more brownish yellow in the subcostal interspaces. Venation: $R_{1+2}$ entire but with distal end pale and lacking trichia; *Rs* very long, about twice the long *m-cu;* cell *1st* $M_2$ large, especially when compared with *profuga;* petiole of cell $M_1$ less than one-half *m*.

Basal abdominal tergites fulvous yellow, narrowly trivittate with brown, the pattern less evident on the outer segments; sternites yellow, with a brownish black central spot before caudal border; subterminal segments more infuscated; hypopygium chiefly yellow. Male hypopygium with the tergite transverse; caudal border with three conspicuous acute points, all with a sharp carina leading backward from tip; median point a broad triangular blade, without lateral shoulders, as in *profuga;* lateral borders of tergite further produced into obtusely rounded lobes. Basistyle with the lobe triangular, its lower angle bearing a pencil of about ten setae, some of unusual length. Outer dististyle elongate, weakly expanded on distal half. Inner dististyle with the head expanded, the setae on outer margin strong and microscopically roughened, forming a linear series of bristles, not a dense outer brush as in *profuga*. Gonapophyses very unequally bilobed, the inner arm a conspicuous elongate blade that is expanded into a flattened spatula. Eighth sternite with its appendage deeply bilobed, broad, with conspicuous setae; this structure is damaged in the unique type and it cannot be affirmed as to whether the median split completely divides the appendage or not.

*Habitat.*—Brazil (Paranà). *Holotype*, ♂, Rio Negro, altitude 600 meters, May 12, 1940 (Father Michael Witte).

The most similar and allied species is *Tipula* (*Eumicrotipula*) *profuga* Alexander, likewise of southeastern Brazil. This differs conspicuously in the coloration of the body and wings, the small cell *1st* $M_2$, and especially in the structure of the male hypopygium, notably the ninth tergite, inner dististyle, and appendage of the eighth sternite.

## Genus **Limonia** Meigen

**Limonia (Limonia) brachycantha** sp. n.

Allied to *repanda;* wings with *Rs* square and spurred at origin, not bent backward; legs with femora brownish black, the distal third yellow, enclosing a broad black ring that is subequal in extent to the yellow subtending annuli vein; *2nd A* not suddenly curved into the anal margin; male hypopygium having the rostral prolongation of the ventral dististyle with a long basal portion, beyond the spines becoming relatively narrow; rostral spines two, short and straight.

*Male.*—Length, about 6.5–7 mm.; wing, 7.2–8 mm.

*Female.*—Length, about 6.5–7.5 mm.; wing, 7.5–8.5 mm.

Rostrum and palpi black, the former relatively long, including the labial palpi about equal to remainder of head. Antennae with scape and pedicel blackened, flagellum infuscated, tinged with greenish; basal flagellar segments subglobular, crowded, the outer ones becoming elongate; terminal segment nearly one-half longer than the penultimate. Anterior vertex silvery yellow, relatively broad, subequal in width to the diameter of scape; head more darkened behind.

Thorax greenish yellow, the pronotum and praescutum with a central black vitta that becomes obsolete just before the suture; mediotergite with a comparable but broader central line; in the holotype, the scutal lobes are undarkened and the posterior border of the scutellum is but weakly infuscated. Halteres uniformly pale green, in some of the paratypes with the knobs slightly darkened. Legs with the coxae and trochanters green or greenish yellow; femora chiefly brownish black, the bases restrictedly paler, with more than the distal third yellow, enclosing a broad black subterminal ring, in the holotype this being subequal in width to the subtending yellow rings; tibiae brown to brownish black; tarsi black, usually with the fore pair somewhat paler. Wings with a strong yellow tinge, the costal border conspicuously more saturated yellow; a restricted but conspicuous dark brown pattern, as follows: A small area at arculus; a narrow common mark over fork of *Sc* and origin of *Rs*, the latter wider; stigma not or scarcely darkened, restricted to isolated spots at ends of the free tip of $Sc_2$ and $R_2$; conspicuous seams over cord and outer end of cell *1st* $M_2$, interconnected along vein $M_{3+4}$; distal sections of veins $M_3$ and $M_4$ seamed; small dark marginal clouds over $R_3$, $M_{1+2}$, *Cu* and *1st A*, very large and conspicuous at *2nd A*, lacking at $R_{4+5}$; veins yellow, darker in the patterned areas. Venation: *Sc* relatively short, $Sc_1$ ending just beyond origin of *Rs*, $Sc_2$ near its tip; *Rs* square at origin, weakly to strongly spurred; *m-cu* before fork of *M* vein; *2nd A* not suddenly curved into the margin.

Abdomen yellow, including the hypopygium; posterior margins of tergites two to six, inclusive, with a narrow but conspicuous dark brown border that ordinarily does not reach the lateral margins. Male hypopygium with the tergite transverse, narrowed outwardly, with very low lobes that are provided with a few scattered long setae. Basistyle with coarse black setae on mesal face; ventromesal lobe simple. Dorsal dististyle a long strong rod, nearly straight for most of its length, thence strongly curved and narrowed to an acute blackened point. Ventral dististyle of moderate size, about one-half more extensive than the basi-

style; rostral prolongation with a long basal portion, the two spines unusually small; apex of prolongation beyond the spines long and narrow, approximately three or four times as long as the spines.

In other specimens regarded as being conspecific, the centers of the scutal lobes are more distinctly darkened; in still more heavily patterned individuals, the dark pattern of the scutal lobes converges behind over the scutellum, leaving the central basal portion of the latter pale. In still other cases, the dark spot on the wings over the fork of *Sc* is disconnected from the one at origin of *Rs*.

*Habitat.*—Peru (Ayacucho). *Holotype*, ♂, Yanamonte, La Mar, in fog forests, altitude 3,000–4,100 meters, August 29, 1941 (Woytkowski). *Allotopotype*, ♀, September 26, 1941. *Paratopotypes*, 7 ♂ ♀, August 31–October 2, 1941.

In its hypopygial structure, *Limonia* (*Limonia*) *brachycantha* comes closest to *L.* (*L.*) *repanda* Alexander, of Ecuador, which differs especially in the leg pattern and in the details of wing venation. In its general appearance, especially the leg pattern, the fly is more like *L.* (*L.*) *meridensis* Alexander, of the Venezuelan Andes, which has the spines of the male hypopygium much longer.

**Limonia (Dicranomyia) maligna** sp. n.

General coloration of thorax pale yellow, with a single, very conspicuous, black median stripe on pronotum and most of praescutum; a narrower dark vitta on mediotergite; head black; scape and pedicel of antennae obscure yellow, the flagellar segments weakly bicolored; knobs of halteres infuscated; legs brownish yellow, the outer tarsal segments dark brown; wings broad, variegated only by the pale brown stigma; $Sc_1$ and $Sc_2$ ending before origin of *Rs; m-cu* at fork of *M;* ovipositor with cerci shorter than the hypovalvae, compressed flattened, with very obtuse tips.

*Female.*—Length, about 8 mm.; wing, 10.5 mm.

Rostrum and palpi black. Antennae with scape and pedicel obscure yellow, flagellum pale brown, somewhat brighter on basal portions of the segments to produce a weak bicolored appearance; flagellar segments oval, the outer ones more elongate; terminal segment nearly one-half longer than the penultimate, constricted and narrowed on apical third. Head black, posterior vertex without pruinosity; anterior vertex a little pruinose, about as wide as the diameter of scape.

Pronotal scutum yellow, with a conspicuous median brownish black line, the scutellum yellow. Mesonotum uniform reddish yellow, the praescutum with a single black stripe that is not quite connected with the pronotal darkening, behind ending some distance before the suture; mediotergite with a very narrow and poorly indicated dusky median line. Pleura and pleurotergite uniformly pale yellow, unpatterned. Halteres with stem yellow, knob infuscated. Legs with coxae and trochanters pale yellow; remainder of legs more obscure yellow, the outer tarsal segments passing into dark brown. Wings broad, whitish subhyaline, scarcely patterned except for the wide, pale brown stigma; a scarcely evident darkening over the anterior cord; costal and prearcular fields a trifle more yellowed than the remainder of ground; veins brown.

Venation: $Sc_1$ ending a short distance before origin of *Rs*, $Sc_2$ some distance from its tip, $Sc_1$ alone a little longer than *r-m;* free tip of $Sc_2$ very short, in transverse alignment with $R_2$; *Rs* arcuated, about one-third longer than basal section of $R_{4+5}$; cell *1st* $M_2$ about as long as vein $M_3$ beyond it; *m-cu* at fork of *M;* vein *2nd A* gently sinuous, long, the cell relatively narrow.

Abdominal segments weakly infuscated, with broad pale caudal borders; genital shield reddish yellow. Ovipositor with the dark-colored cerci compressed-flattened, unusually short, wide, their tips very obtuse; hypovalvae projecting a short distance beyond the tips of the cerci.

*Habitat.*—Peru (Ayacucho). *Holotype*, ♀, Yanamonte, La Mar, in fog forests, altitude 3,000–4,100 meters, October 2, 1941 (Woytkowski).

*Limonia* (*Dicranomyia*) *maligna* is quite different from all of the now numerous regional species of the subgenus. The type of thoracic pattern is found in certain Holarctic species but had not been recorded in the present fauna. The structure of the ovipositor is peculiar and indicates a somewhat isolated species of fly.

**Limonia (Dicranomyia) pennifera** sp. n.

General coloration of thorax reddish brown, the praescutum with three brownish black stripes; rostrum and antennae uniformly blackened; thoracic pleura uniformly reddish brown; halteres long and slender, black; femora obscure yellow, narrowly more blackened at tips; wings brownish gray, variegated only by the slightly darker stigma; *m-cu* a short distance before fork of *M;* male hypopygium with the lobes of ninth tergite squarely truncated; face of basistyle bearing a curved appendage, the outer margin of which bears about fifteen strong spinous setae; gonapophyses with numerous tubercles near base of mesal-apical lobe, the face of the apophysis with a lateral flange.

*Male.*—Length, about 8–8.5 mm.; wing, 10–10.5 mm.

Rostrum black, relatively long, exceeding one-half of the remainder of head; palpi black. Antennae black; flagellar segments long-oval; terminal segment a trifle longer than the penultimate. Head brownish gray; anterior vertex moderately wide, somewhat less than twice the diameter of scape.

Pronotum dark brown, paler laterally. Mesonotal praescutum reddish brown with three nearly confluent brownish black stripes, the posterior interspaces very obscure; scutal lobes similarly darkened, the central area and the scutellum pale, the latter restrictedly more darkened at base; postnotum reddish brown. Pleura uniform reddish brown. Halteres long and slender, black, the base of stem restrictedly pale. Legs with coxae reddish yellow, the fore pair a trifle more darkened; trochanters yellow; femora obscure yellow, the tips narrowly more blackened; tibiae and tarsi brownish black. Wings with an almost uniform brownish gray suffusion, variegated only by the long-oval, slightly darker stigma; veins brown, with obliterative areas over fork of *Rs* and at posterior end of *r-m*. Venation: *Sc* short, $Sc_1$ ending a short distance before origin of *Rs*, $Sc_2$ some distance from its tip, $Sc_1$ alone exceeding *r-m; Rs* weakly angulated at origin, only a little

longer than the basal section of $R_{4+5}$; cell *1st* $M_2$ a little shorter than vein $M_4$ beyond it; *m-cu* a short distance before fork of *M;* vein *2nd A* sinuous.

Abdominal tergites dark brown, the posterior borders of the segments narrowly paler; sternites obscure yellow; hypopygium a trifle brightened. Male hypopygium with the tergite transverse, its caudal margin with a small but narrow median notch, the lateral lobes broad with truncated apices. Basistyle with ventromesal lobe simple; on face of style near base of lobe with a conspicuous curved appendage that is margined with about 13 to 15 strong spines; inner margin of style with additional strong scattered setae. Dorsal dististyle a strong sickle, the apex long-produced. Ventral dististyle large and fleshy, its area exceeding twice that of the basistyle; rostral prolongation small, bearing two strong spines, the more basal one from a strong tubercle on outer margin of prolongation, the outer spine more lateral in position. Gonapophyses with mesal-apical lobe stout, at apex produced laterad into a small point, the inner edge with a small notch; surface of body of style at base of lobe with numerous roughened papillae; face of apophysis with a lateral flange.

*Habitat.*—Peru (Ayacucho). *Holotype*, ♂, Yanamonte, La Mar, in fog forests, altitude 3,000–4,100 meters, September 9, 1941 (Woytkowski). *Paratopotype*, ♂, October 3, 1941.

The most similar species is *Limonia* (*Dicranomyia*) *quadrituberculata* Alexander, of Colombia, which differs in its general appearance and in all details of structure of the hypopygium, especially the rostral prolongation of the ventral dististyle and the conformation of the winglike lobe of the basistyle.

**Limonia (Dicranomyia) claribasis** sp. n.

General coloration greenish yellow, the praescutum with a single broad and conspicuous black stripe; antennae black throughout; thoracic pleura greenish yellow, conspicuously patterned with dark brown; knobs of halteres brownish black; fore coxae blackened, the others pale; femora dusky, the tips broadly yellow; wings whitish subhyaline, variegated with brown, including two disconnected areas along cord, additional to the darker stigma; no dark markings on basal two-thirds of wing; abdominal tergites bicolored, brownish black subbasally, the narrow bases and broad tips yellow; male hypopygium with the gonapophyses smooth, the mesalapical lobe a slender curved hook.

*Male.*—Length, about 7 mm.; wing, 8.5 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval. Head dark brownish gray, somewhat paler behind; anterior vertex moderately wide, approximately twice the diameter of scape.

Pronotum brownish black medially, paler on sides. Mesonotal praescutum obscure greenish yellow with a single broad and conspicuous black median stripe, the usual lateral pair lacking; scutal lobes uniformly brownish black, the median region obscure yellow; posterior sclerites of notum black, the scutellum with a pale central line; pleurotergite greenish on posterior portion, more infuscated on proximal half. Pleura greenish yellow, conspicuously patterned with dark

brown on the propleura and anepisternum, the pteropleurite uniformly green. Halteres relatively long and slender, stem pale, greenish at base, knob brownish black; outer portion of stem with long erect setae. Legs with fore coxae extensively blackened, the remaining pairs greenish testaceous; trochanters greenish; femora dusky, brighter basally, the tips rather broadly and conspicuously yellow; tibiae and tarsi dark brown to brownish black. Wings whitish subhyaline, variegated with brown, including the oval, darker brown stigma and two extensive paler brown clouds, one over the fork of *Rs*, confluent with the stigma, the other over *Cu* at its junction with *m-cu;* the entire basal two-thirds of wing without darkenings; veins pale, somewhat darker in the clouded portions, except in the obliterative fields. Venation: $Sc_1$ ending just before origin of *Rs*, $Sc_2$ a short distance from its tip, $Sc_1$ alone about as long as *r-m;* *Rs* about twice the basal section of $R_{4+5}$; free tip of $Sc_2$ and $R_2$ in transverse alignment; cell *1st* $M_2$ about as long as vein $M_4$ beyond it; *m-cu* shortly before fork of *M*.

Abdominal tergites bicolored, the subbasal half or nearly so brownish black, the very narrow bases and broad apices abruptly yellow, on the subterminal segments the dark color more reduced; sternites and hypopygium pale. Male hypopygium with its general structure much as in *flavofascialis* and allies, differing especially in the gonapophyses. Ninth tergite with the lateral lobes obliquely truncate, the median notch very broadly and shallowly V-shaped. Ventral dististyle much more extensive than the basistyle; rostral prolongation short and obtuse, with the two spines exceeding the prolongation; on lower margin of rostrum with three strong, flattened setae. Gonapophyses entirely smooth, without spinous points; mesal-apical lobe a slender, strongly curved hook, its tip acute.

*Habitat.*—Peru (Ayacucho). *Holotype*, ♂, Yanamonte, La Mar, in fog forests, altitude 3,000–4,100 meters, September 3, 1941 (Woytkowski). *Paratopotypes*, 2 ♂♂.

There are various allied and generally similar species, such as *Limonia* (*Dicranomyia*) *alboapicalis* (Alexander), of Chile and Andean Argentina; *L.* (*D.*) *andicola* (Alexander), of Bolivia; *L.* (*D.*) *flavofascialis* (Alexander), of Argentina, and others. The present fly differs conspicuously in the wing pattern, body coloration, and in the details of structure of the male hypopygium, as the gonapophyses.

**Limonia (Dicranomyia) titicacana** sp. n.

Size relatively large (wing, male, over 12 mm.); mesonotum obscure yellow, the praescutum with three conspicuous dark brown stripes; posterior sclerites of notum and the pleura patterned with brown; legs pale brown, the outer tarsal segments blackened; wings whitish subhyaline, restrictedly patterned with darker; stigma pale; a darkened seam in cell *M* adjoining vein *Cu;* male hypopygium with the tergite long, its caudal margin with a narrow median notch, the conspicuous lobes slightly emarginate, blackened; ventral dististyle large, its rostral prolongation with two spines, the apex with unusually long and conspicuous setae.

*Male.*—Length, about 11 mm.; wing, 12.5 mm.

Rostrum brownish yellow; palpi black. Antennae black, the basal half of scape obscure yellow, the pedicel a little paler than the flagellum; flagellar segments long-oval. Head dark gray, variegated with light gray on front and as a narrow central line on posterior vertex; anterior vertex relatively wide, about twice the diameter of scape.

Pronotum dark brown, paling to yellow on sides. Mesonotal praescutum with the ground obscure yellow, clearer on sides; three conspicuous, dark brown stripes, the median one widened behind and with a shallow median pale line; scutal lobes conspicuously dark brown, the median area and posterior lateral angles of lobes yellow; scutellum obscure yellow medially, slightly infuscated on either side of midline; mediotergite obscure yellow on sides of the cephalic half, more infuscated behind; pleurotergite weakly infuscated. Pleura obscure yellow, striped with medium brown, especially a more dorsal stripe from the sides of the pronotum and fore coxae, crossing the anepisternum and dorsal pteropleurite onto the pleurotergite; ventral sternopleurite less conspicuously darkened. Halteres relatively long, infuscated, the basal half of stem yellow. Legs with the fore coxae darkened, as described, the remaining coxae and all trochanters clear yellow; remainder of legs pale brown, the femoral bases clearer; outer tarsal segments passing into black. Wings whitish subhyaline, only slightly patterned with darker; stigma relatively large but very pale, a little heavier adjoining the veins; a darkened seam in cell *M* adjoining vein *Cu;* wing axilla narrowly darkened; veins brown. Venation: *Sc* short, $Sc_1$ ending just before origin of *Rs*, $Sc_2$ removed from its tip, $Sc_1$ alone about one-half the basal section of $R_{4+5}$; cell *1st* $M_2$ long, approximately equal to the distal section of $M_{1+2}$; *m-cu* a short distance beyond fork of *M;* vein *2nd A* gently sinuous.

Abdominal tergites dark brown, the extreme caudal margins pale; sternites yellow, with a broad median brown stripe, the caudal borders narrowly pale; outer abdominal segments more uniformly darkened; eighth tergite paler; ninth tergite pale excepting the darkened lobes; basistyles dark, ventral dististyles conspicuously pale. Male hypopygium with the ninth tergite relatively long, the length subequal to the width opposite midlength; caudal margin with a very deep and narrow median notch, the lobes broad, each weakly emarginate to produce a conspicuous mesal lobule and a low broad lateral shoulder; lobes conspicuously fringed with setae. Basistyle relatively small; ventromesal lobe simple. Dorsal dististyle small, strongly curved to the narrowly obtuse tip. Ventral dististyle large and fleshy; rostral prolongation small, stout, with two short, slightly unequal spines that are placed close together on outer face near base; spines subequal to or a little shorter than the apex of prolongation beyond their insertion; rostrum obtuse, provided with unusually numerous and conspicuous setae. Gonapophyses broad, smooth, the mesal-apical lobe stout, its lateral angle produced laterad into a sharp point.

*Habitat.*—Peru (Puno). *Holotype*, ♂, Chucuito, near Lake Titicaca, altitude 12,500 feet, April 7, 1939 (J. A. Smyth).

*Limonia* (*Dicranomyia*) *titicacana*, while generally similar to various other high Andean members of the subgenus, differs conspicuously

in the structure of the male hypopygium, especially the tergite and the rostral prolongation. Among such similar but not necessarily closely allied forms are the various species centering around *L.* (*D.*) *andicola* (Alexander) and *L.* (*D.*) *punoensis* Alexander.

**Limonia (Geranomyia) amoenalis** sp. n.

General coloration gray, the praescutum with five black stripes; rostrum and antennae black; knobs of halteres blackened; femora weakly infuscated, with a broad brownish black subterminal ring, the actual tip narrowly yellow; wings grayish subhyaline, patterned with dark brown costal areas and brownish gray washes; third dark costal area a common one over fork of *Sc* and origin of *Rs;* male hypopygium with the rostral prolongation of the ventral dististyle bearing on its outer margin a very conspicuous flattened plate having the usual spines at the two outer angles; spines elongate, the outer one curved; gonapophyses with mesal-apical lobe long and slender, blackened, the tip acute.

*Male.*—Length, excluding rostrum, about 6.5 mm.; wing, 8 mm.; rostrum, about 3 mm.

Rostrum relatively long, black throughout. Antennae black throughout; flagellar segments cylindrical or nearly so, with inconspicuous verticils; terminal segment fully one-half longer than the penultimate. Head light gray, the posterior vertex with a conspicuous blackened area on either side of the ground median vitta.

Pronotum gray, with three black stripes. Mesonotal praescutum gray, with five narrow black stripes, the intermediate group of three slightly wider than the interspaces; lateral pair not reaching the margin; humeral region a trifle more buffy; scutum gray, the lobes rather weakly patterned with brown; scutellum testaceous brown, sparsely pruinose; postnotum gray. Pleura dark plumbeous gray; dorsopleural membrane dark. Halteres with stem light yellow, knob blackened. Legs with coxae yellow, the fore pair more blackened basally; trochanters yellow; femora chiefly infuscated, the bases narrowly clear, with a broad brownish black subterminal ring that is preceded by a very vague and diffuse more yellow band, the actual tip narrowly yellow; tibiae and tarsi brownish black to black; claws with a long basal spine. Wings grayish subhyaline, handsomely patterned with dark brown and more brownish gray; the darker areas appear as a series of four large costal areas, the first at and beyond arculus, the third a large common mark over fork of *Sc* and origin of *Rs*, much restricted in the radial field; last dark area at stigma; somewhat paler markings along cord, outer end of cell *1st* $M_2$ and at ends of the veins, most evident at $R_3$ and the anal veins; subcostal interspace between the second and third dark area conspicuously yellow; veins brown, paler brownish yellow in the ground fields, clear yellow in the costal interspaces. Venation: *Sc* moderately long, $Sc_1$ ending about opposite one-third to one-fourth the length of *Rs*, $Sc_2$ near its tip; *Rs* long, approximately three times the basal section of $R_{4+5}$; cell *1st* $M_2$ long, subequal to vein $M_{1+2}$ beyond it; *m-cu* a short distance beyond fork of *M;* vein *2nd A* gently sinuous.

Abdomen brownish black, the caudal borders of the segments restrictedly paler; hypopygium blackened. Male hypopygium with the tergal

margin with a broad U-shaped notch, the lateral lobes obtuse, with thickened margins that are provided with numerous long setae. Basistyle small, its area a little less than one-third that of the ventral dististyle; ventromesal lobe simple, relatively narrow. Dorsal dististyle a slightly curved rod, slightly widened before the very slender acute tip. Ventral dististyle with the rostral prolongation short and stout, its outer margin at base with a very conspicuous flattened basal tubercle or plate that is wider at its base than it is long; at apical angles of plate with two long spines, the outer one curved, the inner one subequal in length and size, straight; spines about one-half longer than the total length of the prolongation. Gonapophyses with mesal-apical lobe long and slender, blackened, very gently curved, the tip acute.

*Habitat.*—Peru (Ayacucho). *Holotype*, ♂, Yanamonte, La Mar, in fog forests, altitude 3,000–4,100 meters, October 9, 1941 (Woytkowski).

Although generally similar in its general appearance to species such as *Limonia* (*Geranomyia*) *diabolica* Alexander and *L.* (*G.*) *plumbeipleura* (Alexander), the present fly has the hypopygium more as in the other wise entirely different *L.* (*G.*) *laudanda* Alexander, but with the structural details entirely distinct.

**Limonia (Geranomyia) anthina** sp. n.

Allied to *glauca;* general coloration greenish yellow, the praescutum with three widely separated dark brown stripes, the median one narrow; rostrum approximately one half the length of body; knobs of halteres blackened; femora brown, the distal third yellow, enclosing a conspicuous black subterminal ring; wings pale yellow, with a heavy brown pattern that is chiefly marginal in distribution; *Sc* relatively long, $Sc_1$ ending about opposite two-fifths to nearly one-half *Rs;* male hypopygium with the ventral dististyle very large, its rostral prolongation small, with two long straight spines from separate but closely approximated tubercles; proctiger very broad and obtuse, setiferous.

*Male.*—Length, excluding rostrum, about 8.5–10 mm.; wing, 8.8–10 mm.; rostrum, about 4.5–5 mm.

*Female.*—Length, excluding rostrum, about 9 mm.; wing, 10 mm.; rostrum, about 4.5 mm.

Rostrum elongate, approximately one-half the length of wing or body, black, the tips of the labial palpi paling to brown. Antennae black; flagellar segments cylindrical to long-cylindrical, exceeding the verticils in length, the longest of the latter unilaterally distributed; terminal segment elongate, more than one-half longer than the penultimate. Head with a light gray median line, the sides of the posterior vertex blackened; anterior vertex narrow, less than one-half the diameter of scape.

Pronotum greenish, more infuscated medially and on sides. Mesonotal praescutum with the ground obscure orange or fulvous, passing into greenish on the humeral portions; three dark brown stripes, the median one unusually narrow, broadest at its posterior end; lateral stripes relatively wide, occupying the extreme lateral border of sclerite, the ground interspaces thus being very wide; scutum with median area grayish testaceous, each lobe obscure orange with a single large and conspicuous dark brown central area; scutellum grayish testaceous, the

posterior border on either side of midline bordered with brownish black; mediotergite with central portion black, narrowly margined on all sides with obscure orange; pleurotergite pale, tinged with green. Pleura pale, suffused with greenish tints, more reddened on mesepisternum. Halteres with stem greenish, especially at base, knob blackened. Legs with coxae and trochanters greenish; femora pale basally, passing into brown; about the distal third is yellow, enclosing a conspicuous black subterminal ring which thus is preceded and followed by subequal yellow annuli; tibiae brownish black; tarsi pale brown. Wings pale yellow, the costal region even more saturated; an unusually heavy and handsome brown pattern that is chiefly marginal in distribution, including four costal areas, as well as major marks along the posterior border; third costal darkening usually a common one, covering both the fork of *Sc* and origin of *Rs;* fourth area confluent with a broad seam along cord, this becoming more widened at tip of vein *Cu;* of the dark marginal clouds, those of $R_{4+5}$ and $M_{1+2}$ are very small, thence becoming larger and more conspicuous, those at *Cu* and the Anal veins unusually striking; outer end of cell *1st* $M_2$ narrowly infuscated; additional brown clouds along vein *Cu* in cell *M* and along the axillary border; veins yellow, brown in the clouded portions. Venation: *Sc* relatively long, $Sc_1$ ending at near two-fifths to one-half the length of *Rs*, $Sc_2$ a short distance from its tip; *Rs* more or less angulated near origin; *r-m* shortened, the distal section of $R_{4+5}$ more or less arcuated at this point; cell *1st* $M_2$ elongate, a little less than the distal section of vein $M_{1+2}$; *m-cu* at or close to fork of *M;* vein *2nd A* very gently sinuous, the cell wide.

Abdominal tergites dark reddish brown, tinted with green, the sternites paler green; ventral dististyles of male conspicuously light yellow. Male hypopygium with the ninth tergite transverse, its caudal border with a broad notch, the lateral lobes low and obtuse, with abundant setae. Basistyle small, its area only about one-third to one-fourth that of the ventral dististyle; ventromesal lobe simple. Dorsal dististyle a gently curved darkened rod, its tip acute. Ventral dististyle elongate; rostral prolongation very small, slender, the two spines on outer face near base, placed close together but from small separate tubercles; spines subequal, exceeding the prolongation in length. Gonapophyses with mesal-apical lobe conspicuous, bearing a lateral flange. Proctiger very broad and obtuse, setiferous.

*Habitat.*—Peru (Ayacucho). *Holotype*, ♂, Yanamonte, La Mar, in fog forests, altitude 3,000–4,100 meters, August 18, 1941 (Woytkowski). *Allotopotype*, ♀, September 3, 1941. *Paratopotypes*, 3 ♂♂, July 26–September 7, 1941.

Among the described species, the present fly is closest to *Limonia* (*Geranomyia*) *glauca* (Alexander) which differs conspicuously in the pattern of the mesonotum, in other less evident details of coloration of the body and wings, and in the structure of the male hypopygium.

**Limonia (Geranomyia) satipoana** sp. n.

Allied to *stenophallus;* mesonotal praescutum with a broad median reddish brown stripe, bordered laterally by more silvery lines; rostrum black, elongate; knobs of halteres infuscated; femora yellow, with a narrow brown subterminal ring; wings brownish yellow, restrictedly

but conspicuously patterned with brown, including a series of five costal areas, the third at origin of *Rs* and the fourth at fork of *Sc* widely separated; *Sc* long, $Sc_1$ ending about opposite four-fifths *Rs* or beyond; male hypopygium with the mesal-apical lobe of gonapophysis appearing as a strong blackened rod, near its tip bent almost at a right angle, the surface with microscopic setulae; aedeagus relatively stout, especially on its basal portion.

*Male.*—Length, excluding rostrum, about 6.5 mm.; wing, 7.6 mm.; rostrum, about 3.4 mm.

*Female.*—Length, excluding rostrum, about 8 mm.; wing, 8 mm.; rostrum, about 4.5 mm.

Rostrum black, the distal half somewhat paler, elongate, approximately one-half the length of wing. Antennae black; flagellar segments cylindrical, the verticils of the more proximal segments elongate, unilaterally distributed. Head with a continuous narrow light gray line extending the entire length of the dorsum, the posterior vertex on either side strongly darkened; anterior vertex narrow, approximately one-fourth as wide as the diameter of scape.

Pronotum reddish brown. Mesonotal praescutum viewed from above broadly reddish brown medially, forming a broad central stripe that is bordered on either side by a silvery line; lateral praescutal borders narrowly darkened; posterior sclerites of notum, including the central portion of scutum, testaceous brown, pruinose; scutal lobes somewhat darker. Pleura reddish brown, vaguely patterned with darker, especially as a central stripe from the fore coxae backward. Halteres with stem obscure yellow, knob infuscated. Legs with coxae yellow, the fore pair darker; trochanters yellow; femora yellow with a narrow but conspicuous brown subterminal ring placed about its own length before the yellow tip; remainder of legs broken. Wings with a strong brownish yellow tinge, the costal border somewhat clearer yellow; a restricted but conspicuous brown pattern, as follows: Postarcular in cell *Sc;* over the supernumerary crossvein in cell *Sc;* origin of *Rs,* extending from vein *Sc* about midway across *R;* fork of *Sc,* this area widely separated from the last; stigma small, subcircular in outline; narrow brown seams along cord and outer end of cell *1st* $M_2$; veins yellow, brown in the patterned areas. Costal fringe (male) short. Venation: *Sc* long, $Sc_1$ ending about opposite four-fifths to five-sixths *Rs*, $Sc_2$ at its tip; *Rs* long, square at origin; cell *1st* $M_2$ elongate, the second section of vein $M_{1+2}$ longer than the distal section; *m-cu* close to fork of *M*, subequal to distal section of $Cu_1$; vein *2nd A* virtually straight for most of its length, the cell relatively narrow.

Abdomen dark brown, sternites somewhat paler; hypopygium more brightened. Male hypopygium with the tergite transverse, its caudal margin with a small, shallow, median notch, the broad lateral lobes with wide thickened margins that are provided with numerous setae; a transverse row of setae behind midlength of sclerite. Basistyle relatively small, its area about two-thirds that of the ventral dististyle; ventromesal lobe simple. Dorsal dististyle a long, slender, strongly curved rod, the long-extended tip acute. Ventral dististyle with its rostral prolongation relatively small and stout, the two spines arising from a more sclerotized tubercle, relatively widely separated; beyond

the spines, the prolongation is relatively narrow, especially when viewed from the side. Gonapophyses with mesal-apical lobe appearing as a strong blackened rod, near its tip bent almost at a right angle into a powerful black spine; surface of rod over most of its length with microscopic setae. Aedeagus much stouter than in *stenophallus*, particularly on basal half, the distal portion narrowed, terminating in two unusually small apical lobes. Proctiger relatively broad, with abundant long coarse setae.

*Habitat.*—Peru (Junin). *Holotype*, ♂, Satipo, Jauja, altitude 800–900 meters, June 22, 1939 (Paprzycki).

Although very similar in its general appearance to *Limonia* (*Geranomyia*) *stenophallus* Alexander, with which it was associated in collections from Satipo, the present fly is entirely distinct, as shown by the structure of the male hypopygium. The pattern of the mesonotal praescutum differs slightly from that of *stenophallus* but in all other respects the general resemblance is very close.

**Limonia (Geranomyia) macta** sp. n.

General coloration of thorax almost uniformly reddish brown, without pattern; rostrum relatively short, less than one-half the body; knobs of halteres weakly infuscated; wings subhyaline, variegated only by the oval brown stigma; $Sc_1$ ending about opposite midlength of *Rs;* male hypopygium with the ventral dististyle approximately three times as extensive as the entire basistyle; rostral prolongation short and stout, its apex very obtuse; rostral spines arising close together from slightly unequal tubercles; gonapophyses with mesal-apical lobe broad at base, the distal fourth narrowed into a dusky subacute point; aedeagus setiferous.

*Male.*—Length, excluding rostrum, about 6 mm.; wing, 6.5 mm.; rostrum, about 2.8 mm.

Rostrum dark brown, relatively short, the recurved tips of the labial palpi especially short; maxillary palpi dark brown. Antennae dark brown; flageller segments short-oval to subcylindrical (outer segments broken). Head discolored, apparently brown (mounted on microscope slide).

Pronotum testaceous yellow. Mesonotum almost uniformly reddish brown, without pattern; median region of scutum and basal portion of scutellum a little darkened. Pleura uniform reddish yellow. Halteres with stem dusky, restrictedly yellow at base, knob weakly infuscated. Legs with coxae and trochanters yellow; remainder of legs broken. Wings subhyaline, variegated only by the oval, medium brown stigma; veins brown. Venation: *Sc* moderately long, $Sc_1$ ending about opposite midlength of *Rs*, $Sc_2$ close to its tip, $Sc_1$ alone about equal to *r-m;* cell *1st* $M_2$ shorter than any of the veins beyond it; *m-cu* a short distance before the fork of *M*.

Abdomen almost uniformly dark brown, the eighth segment and basal portions of ninth tergite paler. Male hypopygium with the tergite moderately notched, the lobes very low and obtuse. Basistyle small, the ventromesal lobe obtuse. Dorsal dististyle a short curved sickle, a little dilated before the straight acute tip. Ventral dististyle relatively large and fleshy, its area at least three times that of the entire

basistyle; rostral prolongation short and stout, its tip very obtuse; rostral spines rising close together from the abbreviated, sloping outer margin of the prolongation, from slightly unequal tubercles; spines moderately long, about equal to the total length of rostrum, very slightly unequal in length, obliquely acute at tips. Gonapophyses with mesal-apical lobe of peculiar conformation, broad at base, the distal fourth narrowed into a more dusky subacute point. Aedeagus conspicuously setiferous.

*Habitat.*—Brazil (Rio de Janeiro). *Holotype*, ♂, Petropolis, altitude 2,700 feet, April 9, 1940 (Borgmeier).

The most similar described species include *Limonia* (*Geranomyia*) *brevispinula* Alexander and *L.* (*G.*) *infamosa* Alexander, which differ in the body coloration, venation, and details of structure of the male hypopygium, especially the tergite, rostral prolongation of the ventral dististyle, and the gonapophyses.

**Limonia (Rhipidia) leda** sp. n.

General coloration of praescutum obscure yellow, with a median brown stripe; scutum and scutellum dark brown, with a pale central area; antennae black, the two subterminal segments yellow; flagellar segments (female) short-unipectinate; head gray, the anterior vertex reduced to a linear strip; thoracic pleura yellow, striped longitudinally with brownish black; posterior tarsi with segments three and four abruptly yellow; wings light cream-yellow, extensively patterned with brown, the center of wing pale; $Sc_1$ ending about opposite three-fourths the length of *Rs*, *m-cu* close to fork of *M;* basal abdominal tergite clear light yellow, the succeeding ones dark brown.

*Female.*—Length, about 8.5 mm.; wing, 9.8 mm.; antenna, about 2 mm.

Rostrum and palpi black, the former slightly produced. Antennae (female) black, the penultimate and antepenultimate segments yellow, contrasting conspicuously with the black terminal segment; flagellar segments one to ten, inclusive, with a stout branch from an oval basal swelling, the longest branch (flagellar segment five or six) a trifle shorter than the segment; apical pedicel more than one-half as long as the swollen base; terminal segment about one-half longer than the penultimate, narrowed to the tip. Head dark gray; anterior vertex reduced to a very narrow strip, less than the diameter of a single row of ommatidia.

Pronotum dark brown medially, obscure yellow on sides. Mesonotal praescutum with the ground obscure yellow, clearer on the humeral portions, with a conspicuous brown median stripe; the usual sublateral stripes lacking but the lateral borders again slightly darkened; viewed from the side, the praescutum appears more or less pruinose; scutal lobes and base of scutellum dark brown, the areas converging to a point behind, the central portion of scutum and scutellum more testaceous; posterior lateral borders of scutellum obscure yellow, the parascutella very slightly darker; mediotergite dark brown on mor than the cephalic half, the remainder pale, including the lateral still wider posterior borders. Pleura and pleurotergite obscure ye with two longitudinal brownish black stripes, the more dorsal

extending from the cervical region across the propleura, anepisternum and pteropleurite onto the ventral pleurotergite; ventral dark stripe including the ventral sternopleurite and meral region, together with the coxal bases; dorsopleural membrane yellow. Halteres black, the extreme base of stem yellow; stem with conspicuous setae. Legs with coxae obscure yellow and brown, as described; trochanters yellow; femora obscure yellow, the tips narrowly dark brown; tibiae and proximal two segments of tarsi pale brown or yellowish brown; on fore and middle legs, remaining tarsal segments uniformly black; on hind legs, segments three and four light yellow, the fifth abruptly black. Wings with the ground light cream yellow, extensively and handsomely patterned with pale brown; stigma long-oval, darker brown, without trichia; the paler areas include major marks along costa, the first over *h* and arculus, the second about midway to the origin of *Rs*, these latter two continued caudad over the base of cells *M* to *1st A* and including most of cell *2nd A;* third costal darkening at origin of *Rs*, almost reaching vein *M* behind; fourth area at fork of *Sc*, virtually confined to the costal and subcostal fields but with an isolated spot immediately behind in cell $R_1$; conspicuous seams along cord and outer end of cell *1st* $M_2$; a broad subterminal wash across all outer cells from $R_2$ to $M_3$, inclusive, the apex again pale; other washes extend from the major basal cloud through cell *Cu* to the margin, involving much of outer end of cell *1st A* adjoining the vein; subcostal areas more extensive than the interspaces; axilla broadly pale; outer ends of cells *R* and *M* broadly pale so the center of wing is extensively unpatterned; veins pale brown, brighter in the yellow ground areas. Venation: *Sc* long, $Sc_1$ ending about opposite three-fourths the length of *Rs*, $Sc_2$ not far from its tip; inner end of cell *1st* $M_2$ somewhat arcuated; cell *1st* $M_2$ about as long as vein $M_4$; *m-cu* at fork of *M*.

Basal abdominal tergite clear light yellow; following tergites chiefly dark brown, the outer ones paler brown with more or less distinct darker borders; sternites obscure yellow, the genital segments more obscure fulvous. Ovipositor with cerci very slender, gently upcurved; hypovalvae long and straight.

*Habitat.*—Peru (Ayacucho). *Holotype*, ♀, Yanamonte, La Mar, in fog forests, altitude 3,000–4,100 meters, September 25, 1941 (Woytkowski).

Although I have only the female sex available, I believe that the present species will be found to belong to the group of species having unipectinate flagellar segments in the male sex, such species including *Limonia* (*Rhipidia*) *breviramosa* Alexander, *L.* (*R.*) *mystica* Alexander, and *L.* (*R.*) *pallatangae* Alexander, all of which differ in the coloration of the antennae and the posterior legs, as well as in details of pattern of the body and wings. The fly further differs from all of those species having bipectinate or tripectinate antennae in the male sex.

## Genus **Helius** St. Fargeau

### **Helius (Helius) multivolus** sp. n.

General coloration black, the praescutum paler; femora obscure brownish yellow, the distal ends blackened to their very tips; tibiae

narrowly snow-white at base, thence abruptly infuscated, this color paling on outer portion of segment; tips of tibiae and the tarsi white; wings strongly tinged with brown; *Sc* long; cell *1st* $M_2$ rectangular, nearly parallel-sided, the longest element being the second section of $M_{1+2}$; *r-m* longer than the basal section of $R_{4+5}$.

*Female.*—Length, about 6 mm.; wing, 5.5 mm.

Rostrum black, a little shorter than remainder of head; palpi black. Antennae with scape and pedicel black; flagellum broken. Head blackened, the narrow anterior vertex more grayish; eyes large.

Cervical region and pronotum black. Mesonotum apparently paler than either the pronotum or pleura, particularly the praescutum. Pleura black. Halteres broken. Legs with the coxae and trochanters black; femora obscure brownish yellow, the distal ends blackened to the very apices of segments; tibiae narrowly but very conspicuously white at base, then abruptly more infuscated, this color gradually fading out to the broad pale tibial tips, the outer ends, with the tarsi, white. Wings with a strong brownish tinge, deepest in prearcular field and in distal ends of outer radial cells; stigma oval, still darker brown, preceded and followed by more whitened areas of approximately the same extent; pale longitudinal streaks, especially one along most of vein *M*, involving the adjoining membrane of both cells *R* and *M*, passing the cord and almost reaching the wing tip along vein $M_4$; somewhat similar whitenings in cells *1st A* and *Cu;* veins brown, more yellowish brown in the costal field. Macrotrichia on outer wing veins from $R_3$ to $M_3$, inclusive. Venation: $Sc_1$ ending a short distance before level of fork of *Rs;* $R_{1+2}$ bent strongly into *C* at its tip; *Rs* a little more than one-half its anterior branch; cell *1st* $M_2$ elongate, nearly parallel-sided, the longest element being the second section of $M_{1+2}$; *r-m* long, exceeding the basal section of $R_{4+5}$; *m* very short, the basal section of $M_3$ correspondingly long; *m-cu* about one-third to one-half its length beyond fork of *M*.

Abdomen black, the valves of the ovipositor elongate, rich fulvous horn color.

*Habitat.*—Peru (Junin). *Holotype*, ♀, Satipo, Jauja, altitude 800–900 meters, September 5, 1940 (Paprzycki).

The closest relative is *Helius* (*Helius*) *acanthostyla* Alexander, of this same general region. This latter is best told by the narrow but abruptly whitened tips of the femora and by distinct venational details, especially the short *Sc* and differently shaped cell *1st* $M_2$.

## Genus **Trentepohlia** Bigot

### **Trentepohlia** (**Paramongoma**) **faustina** sp. n.

Size large (wing, female, 10 mm.); general coloration of mesonotal praescutum and the pleura yellow; mediotergite dark brownish gray; femora yellow, the tips rather broadly and conspicuously snowy-white, preceded by a subequal dark brown ring; tibiae white, the basal third weakly infuscated; remainder of legs white; wings yellow, stigmal area conspicuous, dark brown, subtriangular in outline; $R_2$ at fork of $R_{2+3+4}$, the latter long and sinuous; vein $R_3$ suberect, its tip more or less evanescent; cell *Cu* narrowed at wing margin; abdomen yellow, the

tergites conspicuously brownish black on their central portions; ovipositor with elongate cerci.

*Female.*—Length, about 12 mm.; wing, 10 mm.

Rostrum yellow; palpi reduced, yellow. Antennae with scape and pedicel obscure brownish yellow; flagellum broken. Head buffy above, the very narrow anterior vertex, broader posterior orbits and the genae light gray.

Pronotum brownish testaceous. Mesonotal praescutum obscure yellow to fulvous yellow, without distinct stripes; interspaces with sparse black setae; scutum obscure yellow, the posterior half of lobes conspicuously infuscated; scutellum broad, testaceous yellow, clearest on central portion, more infuscated on sides; mediotergite dark brownish gray. Pleura and pleurotergite yellow. Halteres yellow, the knobs more infuscated. Legs with the coxae and trochanters yellow; femora yellow, the tips rather broadly and conspicuously snowy-white, preceded by a darker brown ring of approximately equal width, this pattern generally similar in amount on all legs; tibiae white, with a broad diffuse darkening on proximal third, beginning just beyond the narrow whitened bases; tarsi snowy-white. Wings yellow, the prearcular and costal fields clearer yellow; stigmal area subtriangular in outline, dark brown, conspicuous; vein *Cu* and the region of cell *1st* $M_2$ slightly more infuscated, indicated chiefly by a darkening of the veins; remaining veins yellow, especially those in the brightened costal portions. Venation: $R_2$ long, gently sinuous, uniting at fork of $R_{2+3+4}$; tip of the suberect vein $R_3$ more or less evanescent; $R_{2+3+4}$ long, nearly twice $R_2$, gently sinuous; *m-cu* at fork of *M;* cell *Cu* unusually narrow at margin, the distance being only about one-sixth *m-cu* or even less.

Abdominal tergites brownish yellow, conspicuously patterned with brownish black on the central portion of each segment, broadly interrupted on the basal rings and more narrowly by the pale posterior borders; sternites yellow. Ovipositor with the valves long and slender, almost straight to very gently upcurved, the tips acute.

*Habitat.*—Brazil (Rio de Janeiro). *Holotype*, ♀, Terezopolis, altitude 920 meters, August 6, 1942 (Lèrio Gomes).

This very distinct species has no close described relative. It is most similar to the Peruvian *Trentepohlia* (*Paramongoma*) *disparilis* Alexander, differing conspicuously in the pattern of the wings and legs and in the very distinct venational details, as the course of veins $R_3$ and $R_{2+3+4}$ and the unusually narrowed cell *Cu*.

## Genus **Cryptolabis** Osten Sacken

### **Cryptolabis (Cryptolabis) hilaris** sp. n.

General coloration of mesonotum uniform light reddish brown, the thoracic pleura with a blackened longitudinal stripe; antennae with scape and pedicel blackened, flagellum abruptly light yellow; head silvery white; fore femora dark brown, with a broad diffuse yellow ring on distal half, the tip darkened; middle and hind femora yellow, the tips narrowly darker; wings whitish subhyaline, handsomely variegated with darker, including a conspicuous darker seam along cord and paler washes at midlength of the cells beyond cord and again across cells

*R* to *Cu* before midlength of wing, these darkenings best shown by the coloration of the veins; vein $M_3$ arising from the upper fork of *M*.

*Female.*—Length, about 3.5 mm.; wing, 4 mm.

Rostrum and palpi pale testaceous yellow. Antennae with scape and pedicel blackened, the flagellum abruptly light yellow; flagellar segments oval, with long conspicuous verticils. Head silvery white; anterior vertex relatively broad.

Pronotum light brown. Mesonotum almost uniform light reddish brown, without conspicuous pattern, the median region of scutum and scutellum more silvery, the latter darkened behind. Pleura reddish, with a longitudinal black stripe across the more dorsal sclerites. Halteres broken. Legs with the coxae and trochanters yellowish testaceous; fore femora narrowly yellow at base, thence dark brown, on distal half with a broad diffuse yellow ring, the tip narrowly darkened; middle and hind femora yellow, the tips very narrowly and inconspicuously darkened; all tibiae yellow with narrow but conspicuous brown tips; basal segments of tarsi yellow, their tips dark brown, the outer segments more uniformly infuscated. Wings whitish subhyaline, sparsely but handsomely patterned with dark brown and pale gray; the darker areas include a seam along cord, broken over the fork of *M*, continued over the distal half of *Rs* and along vein $Cu_1$ for a short distance proximad of *m-cu;* axillary border darkened; the gray washes include a subterminal band across the outer cells, best-evidenced by the darkened color of the veins; a second gray cloud before midlength of wing, crossing cell *M* and involving the adjoining parts of *R* and *Cu*, the veins not conspicuously darkened in this area; veins light yellow except in the patterned areas, as described, deepest along cord. Macrotrichia of cells relatively sparse, in $R_2$ to $M_4$ inclusive, chiefly in the distal halves of the cells. Venation: *h* lacking; *Rs* relatively short and oblique, less than twice $R_{2+3+4}$; $R_{2+3}$ erect and transverse, $R_2$ directed basad, subequal in length to $R_{2+3}$; a short basal section of vein $R_5$; vein $M_3$ arising from the upper fork of *M*.

Abdomen darkened, discolored by masses of eggs within body. Ovipositor with valves very small and inconspicuous.

*Habitat.*—Peru (Junin). *Holotype*, ♀, Satipo, Jauja, altitude 800–900 meters, March 6, 1941 (Paprzycki).

Readily distinguished from other generally similar species of the subgenus by the pattern and venation of wings, especially the gray washes before midlength of wing and again before the apex, and by the unique basal position of vein $M_3$.

**Cryptolabis (Cryptolabis) jovialis** sp. n.

Mesonotal praescutum and scutum light chestnut brown, the pronotum and head china-white; thoracic pleura white dorsally, with a broad black ventral stripe; fore coxae and bases of middle coxae infuscated; fore femora brownish black, remaining femora yellow with narrow brownish black tips; wings whitish subhyaline, particularly the basal portion; a scarcely evident darkening along cord; no darkening along vein *Cu* or in axillary region; *Rs* oblique, sinuous; *r-m* at fork of *Rs*.

*Female.*—Length, about 4–4.2 mm.; wing, 4.5–4.7 mm.

Rostrum and palpi black. Antennae with scape and pedicel black, flagellum brown; flagellar segments oval, gradually decreasing in size outwardly. Head abruptly china-white.

Pronotum china-white. Mesonotal praescutum light chestnut brown to slightly darker brown, in the type slightly more pruinose behind; humeral region extensively whitened; scutal lobes concolorous with the praescutum; posterior sclerites of notum darker. Pleura conspicuously striped with black and white, the former including a broad ventral stripe from the fore coxae backward, crossing the ventral pleurites to the abdomen, enclosing the root of the haltere; the white stripe includes the dorsal pleurites and dorsopleural membrane, involving the anapleurotergite and extreme lateral portion of the mediotergite. Halteres dusky, the base of stem obscure white. Legs with coxae obscure yellow, the fore pair darker, the base of middle coxae narrowly blackened; fore femora black, remaining femora yellow with narrow brownish black tips; tibiae brownish yellow, the tips narrowly infuscated; tarsi brownish black, the proximal portions of basitarsi more yellowed. Wings whitish subhyaline, particularly the basal third to half; a scarcely evident darkening along cord, best indicated by an increase in intensity of the inclosed veins; no darkening along *Cu* or in axillary region; veins brown, paler in the brightened basal fields. Macrotrichia of cells moderately abundant, occupying the central portions of outer ends of cells $R_2$ and $M_4$, inclusive, with a few further scattered trichia near outer end of cell *Cu*, and, in paratype, even in cell *1st A*. Venation: *Rs* oblique, rather strongly sinuous; $R_2$ in nearly vertical alignment with $R_{2+3}$; *r-m* at fork of *Rs*, obliterating the basal section of $R_5$; *m-cu* variable in position, from opposite mid-length to about opposite five-sixths the length of $M_{3+4}$.

Abdomen dark brown, the sternites with borders of segments narrowly paler; abdomen of female filled with large black eggs.

*Habitat.*—Peru (Ayacucho). *Holotype*, ♀, Ayna, La Mar, altitude 2,400 meters, May 18, 1941 (Woytkowski). *Paratopotype*, ♀.

*Cryptolabis* (*Cryptolabis*) *jovialis* is closest to *C.* (*C.*) *varipes* Alexander, of Costa Rica, differing especially in the coloration of the body and wings, especially the latter, where the dark pattern is so restricted as to be virtually lacking.

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HESPERIIDARUM REI PUBLICAE AEQUATORIS CATALOGUS, by Roswell C. Williams, Jr., and Kenneth J. Hayward. Acta Zoologica Lilloana, Vol. II, No. 1, pp. 63–246, 1944.

Although little can be said of a catalog in review, no taxonomist who has worked on the South American fauna can fail to appreciate the importance of such works. Messrs. Williams and Hayward have included references to original descriptions of both genera and species and their synonyms, known localities, occasional explanatory notes and a full index. The catalog will be of great value to students of the South American skippers. Even though it deals only with the fauna of Ecuador, the writers consulted such a wealth of material that its practical value will extend far beyond that geographical limit.—A. W. L.

# THE MORPHOLOGY OF THE MOUTHPARTS OF THE NON-BITING BLACKFLY, EUSIMULIUM DACOTENSE D. & S., AS COMPARED WITH THOSE OF THE BITING SPECIES, SIMULIUM VENUSTUM SAY

## (Diptera: Simuliidae)[1] [2]

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### INTRODUCTION

The Simuliidae have for many years attracted attention because of their blood-sucking habits and vicious manner of attacking man and animals; and more recently, because of their role in the transmission of pathogenic organisms. The mouthparts of various species of this family have been studied and described by a number of writers, but the work of these men has been limited mostly to the study of the female mouthparts, no doubt because those of the male are not constructed for blood-sucking.

It had long been suspected by students of this group that the females of some species were not blood-feeders. However, the only basis for this assumption was the fact that these species had never been observed to bite. It remained for Dorogostajskij et al (1935) to show that the mouthparts of the female *Prosimulium alpestre* D., R. & V., a Siberian species, were so weakly developed that they could not be used to puncture the skin of an animal; and for Krafchick (1942) to show, on the basis of muscular development, that an American species, *Eusimulium lascivum* Twinn,[3] is not a blood feeder.

It has been shown in the present study, on the basis of morphological development, that *Eusimulium dacotense* D. & S. is a species in which the female mouthparts are not fitted for biting, the mandibles being thin and almost membranous and the maxillae being weakly sclerotized and armed only with long setae. The remainder of the mouthparts are as well or almost as well developed as the corresponding parts of the biting species with which they are compared. Therefore *E. dacotense* seems capable of taking liquid food if it so desires.

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[1]The writer wishes to express his sincere appreciation to Drs. C. E. Mickel and W. A. Riley for their many helpful suggestions during this study and for reading the manuscript, and to Drs. M. H. Haydak and A. A. Granovsky for the translation of Serbian and Russian papers.

[2]Paper No. 2162 Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul.

[3]*Simulium* (*Eusimulium*) *lascivum* Twinn, Canadian Jour. Res., Sec. D., Vol. 14, 1936, is here presented as a synonym of *Eusimulium dacotense* D. & S., Proc. U. S. Nat. Mus., Vol. 69, Art. 10, 1927. This synonymy was proved by the writer and Dr. Alan Stone of the U. S. Dept. of Agriculture, Bur. Entomology and Plant Quarantine, by comparing paratypes of Dyar and Shannon's species with specimens determined by Twinn as *S. lascivum*.

It is the purpose of the writer in this paper to show the similarity in the degree of development of the male and female mouthparts in *E. dacotense*, and to compare these mouthparts with those of the female of *Simulium venustum* Say, a species known over a large part of North America for the severity of its attack.

### THE HEAD CAPSULE

The heads of Simuliids are hypognathous in type. The mouthparts are short in comparison with those of other blood-sucking Diptera and closely resemble those of *Culicoides pulicaris* L. which were thoroughly described by Jobling (1928). The frontal and lateral aspects of the head are largely occupied by the compound eyes which are holoptic in the male (C. E., fig. 1) and dioptic in the female (C. E., fig. 2). The vertex (V., figs. 1, 2 and 3) occupies the area between the occiput and the membranous antennal sockets and is bounded laterally by the compound eyes. A short stem of the epicranial suture is present (E. S., figs. 1 and 2), but the arms cannot be distinguished.

The frons, although considered by most writers to be fused with the clypeus, is shown by Snodgrass (1943) to be separated from it but nearly obliterated between the antennae where it exists as an almost membranous area. The clypeus (C., figs. 1, 2 and 3), which is a prominent shield-like sclerite, lies directly ventrad of the narrow frons and is bounded laterally by the compound eyes, and ventrally by the labrum-epipharynx. It is a convex structure essentially the same in the females of both species studied, but in the male *E. dacotense* it is smaller.

The antennae are situated between the ventral margin of the vertex and the frons (figs. 1 and 2). They are attached to the head-capsule

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KEY TO FIGURE LETTERING

| | | | |
|---|---|---|---|
| A. P. | Antero-lateral process of clypeus | M. | Postmentum |
| C. | Clypeus | M. C. | Mandibular condyle |
| Cb. | Cibarial pump | Md. | Mandible |
| C. E. | Compound eye | M. P. | Median process of labrum |
| Co. | Cornua | O. | Occiput |
| D. | Depression | O. C. | Occipital condyle |
| D. P. | Dorsal projection | O. F. | Occipital foramen |
| D. W. Cb. | Dorsal wall of cibarium | O. S. D. | Orifice of salivary duct |
| E. | Epipharynx | P. | Maxillary palp |
| E. S. | Epicranial suture | Pg. | Postgena |
| F. Ch. | Food channel | Ph. | Pharyngeal pump |
| G. | Gena | P. M. | Pseudotendon of mandible |
| Ga. | Galea | P. P. | Posterior process of labrum |
| H. | Hypopharynx | S. | Stipes |
| Il. | Interlora | S. D. | Salivary duct |
| I. P. A. T. | Invagination of posterior arm of tentorium | S. O. | Sense organ |
| | | S. P. | Sensory peg |
| L. | Labium | T. | Torma |
| La. | Lacinia | Th. | Theca |
| Lb. | Labellum | T. T. | Terminal teeth |
| Li. | Ligula | V. | Vertex |
| L. P. | Lateral process of labrum | 1 Lb. | First segment of labellum |
| Lre. | Labrum-epipharynx | 2 Lb. | Second segment of labellum |

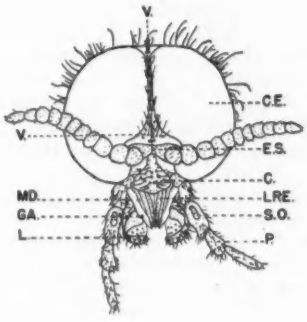



FIG. 1

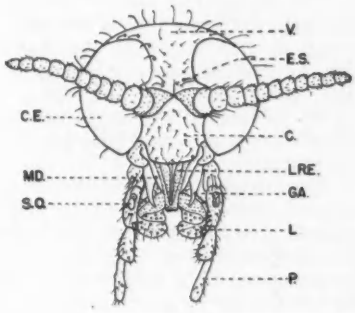



FIG. 2.

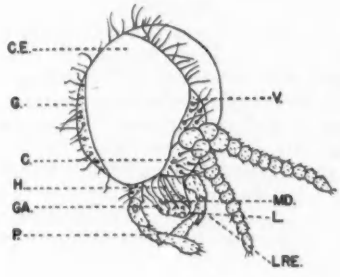



FIG. 3.

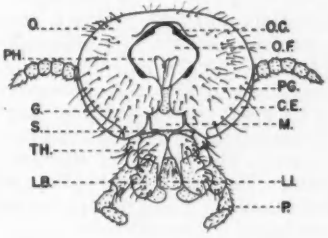



FIG. 4.

FIGURES 1–4. *Eusimulium dacotense* D. & S. 1. Frontal view of head of male. 2. Frontal view of head of female. 3. Lateral view of head of male. 4. Posterior view of head of female.

by means of the membranous antacoriae, the antennal sclerites being absent. They are eleven segmented in both species studied.

The occipital foramen (O. F., fig. 4) is situated medially and dorsally on the posterior surface of the head. It is roughly round in shape with a partial constriction at the dorsal side. The projections formed by this constriction are the occipital condyles (O. C., fig. 4) to which the "neck sclerites" articulate. The occiput (O., fig. 4), according to Jobling (1928), comprises the area dorsad of an imaginary line drawn across the head through the occipital condyles, and ventrad of the vertex.

The postgenae (Pg., fig. 4) occupy the area ventrad of this imaginary line and extend laterally to fuse with the genae (G., figs. 3 and 4) which, according to Snodgrass (1935), comprise the area behind and beneath the compound eyes. Ventrad of the occipital foramen the postgenae are separated by a narrow membranous strip, but fuse below with the stipites (S., fig. 4) and with a ventral plate (M., fig. 4) which is called the postmentum by Snodgrass (1943).

### GENERAL ACCOUNT OF THE MOUTHPARTS

The mouthparts of the Simuliidae, both external and internal, comprise the same parts as are found in other blood-sucking Nemocera; namely, the maxillae, mandibles, labrum-epipharynx, hypopharynx, labium, and the cibarial and pharyngeal pumps. As pointed out by Snodgrass (1943), the latter two parts have more frequently been referred to as the "pharyngeal" and "oesophageal" pumps. The arrangement of the mouthparts is shown diagramatically in cross section in fig. 24. The mandibles are interposed between the labrum-epipharynx and hypopharynx, thus forming the food channel (F. Ch., fig. 24) between the labrum-epipharynx and mandibles. The salivary duct (S. D., fig. 24) extends throughout the length of the hypopharynx. It exists as a groove in *E. dacotense* (figs. 17 and 18) while in *S. venustum* it is enclosed on the proximal half (fig. 19). The galeae (Ga., fig. 24) of the maxillae are held laterad to the mandibles and somewhat ventrad of them. The whole is surrounded laterally and ventrally by the labium. The palps are held outside the labial sheath. The first two segments of the palps occupy positions at the sides of the theca and aid in enclosing the mouthparts.

### THE MAXILLAE

The maxillae are paired structures arising from and partially composing the posterior surface of the head (figs. 5 and 7). The exact homology of certain parts of these appendages has long been a source of argument. In the Simuliidae each maxilla consists of the stipes (S), galea (Ga), palp (P), and a bar-like structure (Il. (La.) ), the homology of which is not understood.

The stipes is roughly rectangular in shape and occupies a position at the base of the head (S., figs. 5 and 7). It is divided by a twist which occurs at the middle. The proximal part is imbedded in the head-capsule and in both species it is bordered laterally by membrane and is fused mesally with the postmentum (M., figs. 5 and 7). Crampton (1923) calls the result of this fusion a "synstipites".

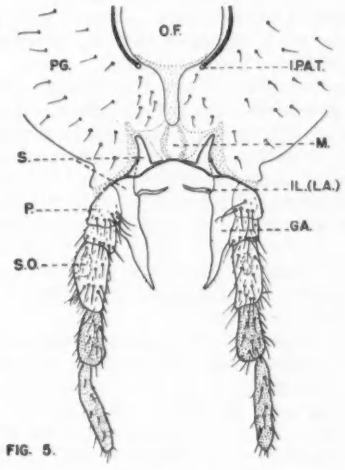



FIG. 5.

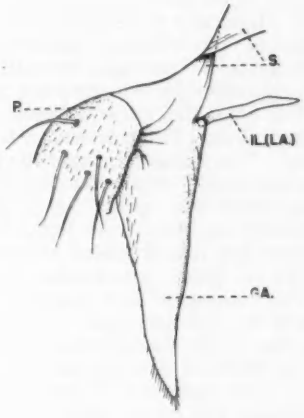



FIG. 6.

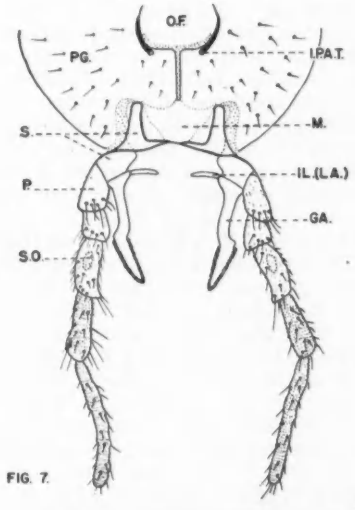



FIG. 7.

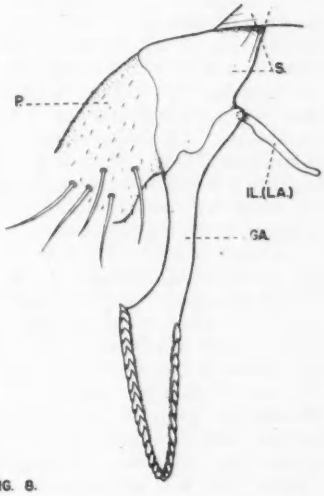



FIG. 8.

FIGURE 5. *Eusimulium dacotense* D. & S., posterior view of head of female showing maxillae. 6. *Eusimulium dacotense* D. & S., enlarged view of galea of male. 7. *Simulium venustum* Say, posterior view of head of female showing maxillae. 8. *Simulium venustum* Say, enlarged view of galea of female.

(For Key to Figure Lettering see page 282.)

The distal part of the stipes is situated beyond the margin of the head. Laterally it is fused with the maxillary palp and distally with the galea. An indistinct suture is present between the palp and stipes. In *E. dacotense* the stipes is continuous with the galea (fig. 6), while in in *S. venustum* the two parts are divided by a suture (fig. 8).

The chief difference between the maxillae of the two species lies in the galeae. For this reason the galeae of each are discussed separately. The galea of *E. dacotense* (fig. 6) is long and triangular in shape, tapering acutely to a point distally. It is thin and weakly sclerotized, being armed only with a few long hairs at its extremity. On the side adjoining the palp it is finely pubescent. Proximally and on the ental margin it is produced as a rounded projection to which a bar-like sclerite (Il. (La.) ) articulates.

The maxillae of both the male and female *E. dacotense* are identical both in size and structure. It is apparent that the galeae in this species (Ga., fig. 6) could not be used effectively in biting.

The galea of *S. venustum* (fig. 8) presents a very different appearance. It is lanceolate in shape when viewed from the anterior aspect. Proximally and on the ental margin it is produced as a rounded projection as was described above in *E. dacotense*. Approximately the distal two-fifths of the galea is broadened and flattened to resemble a spearhead in shape. This flattened part bears 31 to 34 sharp retrose teeth at its margin. It has been stated by some writer that these teeth occur on the anterior face of the galea, but if the galea is examined from a lateral view it will be seen that they occur on the posterior face and that the anterior face is smooth. Jobling (1928), who made a study of the muscles controlling the galea in *Culicoides pulicaris* L., concluded that the main movements of these parts consisted of protraction and retraction. Gibbins (1938) stated, concerning the galeae of *Simulium damnosum* Theob., that they make a very efficient tearing apparatus, and are not used for piercing or cutting but for enlarging the initial cut made by the mandibles. Those of *S. venustum* appear admirably adapted to such a purpose.

A narrow sclerotized bar (Il. (La.), figs. 5, 6, 7 and 8) arises from the ventro-ental margin of the galea at its proximal end and extends mesad to attach latero-distally to the cibarial pump (figs. 13, 17, 18 and 19). Patton and Cragg (1913) have been credited with homologizing this structure in Tabanidae with the lacinia. However, they have been misquoted since they describe the lacinia as a "short peg-shaped projection" and label such a projection in their plate of *Haematopa pluvialis* as lacinia. They do not describe or figure a bar-like structure such as is found in the Simuliidae. Peterson (1916) stated that this piece in Simulium is apparently homologous with the lacinia. He was mistaken in believing that it articulates between the stipes and the hypopharynx. Crampton (1923) considered the structure to be homologous with the "interlora" of Hymenoptera.

The maxillary palps of both species differ very little from one another. The palp is attached at its proximal end to the stipes. It consists of five segments, each of which bears long setae. The first segment was considered the palpifer by Emery (1913).

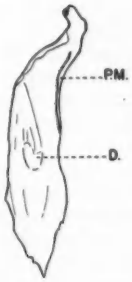



FIG. 9.

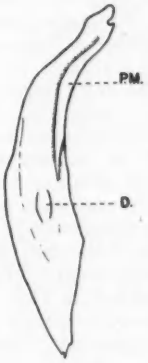



FIG. 10.

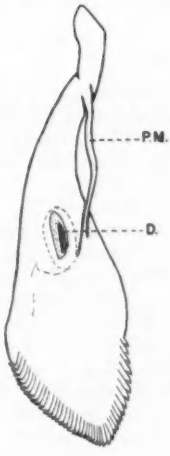



FIG. 11.

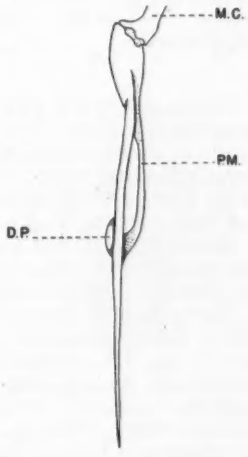



FIG. 12.

FIGURE 9. *Eusimulium dacotense* D. & S., mandible of male. 10. *Eusimulium dacotense* D. & S., mandible of female. 11. *Simulium venustum* Say, mandible of female. 12. *Simulium venustum* Say, lateral view of mandible of female.

(For Key to Figure Lettering see page 282.)

Smart (1935) and Krafchick (1942) considered the first two segments of the palp as a single segment since they are partially fused. However, the intersegmental suture is distinct and they must, therefore, be considered as two segments even though they are immovably joined to one another.

The third segment of the palp is dilated somewhat and bears a sensory vesicle (S. O., figs. 1, 2, 5 and 7) internally. This organ is foot-shaped when viewed laterally (fig. 5) and opens to the exterior on the dorsal surface of the palp. The walls of the vesicle are extremely uneven, giving it a cinder-like appearance.

A longitudinal section through the palp (fig. 25) shows the vesicle to be filled with long, extremely thin-walled, spatulate sensillae set in pits in the wall of the organ, and with numerous short pointed setae between them. Preliminary histological sections show a large flask-shaped cell at the base of each of the spatulate sensillae. The neck of the organ is set with long, outward-projecting setae which apparently act to prevent objects from entering. This organ is as well developed in the male as in the female and is the same in *S. venustum* as in *E. dacotense*.

Jobling (1928) described an organ on the third segment of the palp of *Culicoides pulicaris* L. which is apparently homologous with the one found in the Simuliidae. However, in *Culicoides* the sensillae are exposed on the surface of the palp instead of being contained in a vesicle. He was able to show that the sensillae are connected with the palpal nerve.

### THE MANDIBLES

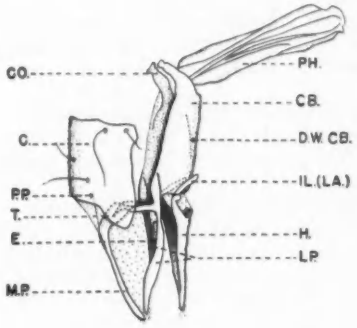
The mandibles of *E. dacotense* (figs. 9 and 10) are blade-like structures which are heavily sclerotized proximally and gradually thin out to almost membrane distally. They are widest about one-third the distance from the distal end. The tips are pointed but lack teeth, and are so thin as to be almost membranous. It does not seem possible that they could be used to cut or puncture the skin.

A clear area (D., figs. 9 and 10) occurs at the middle of each mandible. This area appears thinner than the surrounding mandible. It is not a depression or projection such as occurs on the mandible of *S. venustum*.

The proximal part of the mandible is thickened and articulates with a lateral process of the clypeus called the mandibular condyle (M. C., fig. 15). Extending from the base of the mandible on the ventral side, running along free of the outer edge, is a sclerotized strip called the "abductor of the mandible" (P. M., figs. 9, 10, 11 and 12) by Gibbins (1938). The use of the term "abductor" indicates that this sclerotized structure is a muscle. Since it is not, the term *pseudotendon of the mandible* is here proposed in its place. This strip joins the mandible again proximad to the clear spot (D).

The mandibles of the male and female *E. dacotense* are identical in structure. Those of the male are approximately three-fourths the size of those of the female (figs. 9 and 10).

The mandibles of the female *S. venustum* (fig. 11) are thin, flat structures more heavily sclerotized than those of *E. dacotense*. The pseudotendon of the mandible (P. M.) is present as in *E. dacotense*, and

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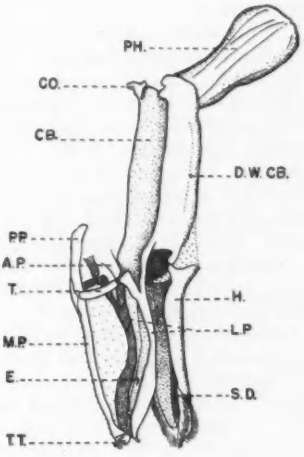


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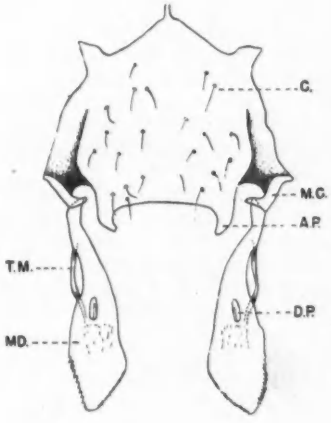


FIG. 15.

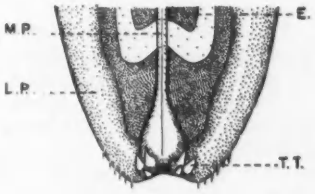


FIG. 16

FIGURE 13. *Eusimulium dacotense* D. & S., lateral view of labrum-epipharynx, hypopharynx, etc., of male. 14. *Simulium venustum* Say, lateral view of labrum-epipharynx, hypopharynx, etc., of female. 15. *Simulium venustum* Say, dorsal view of clypeus and mandibles of female. 16. *Simulium venustum* Say, dorsal view of tip of labrum-epipharynx of female.

(For Key to Figure Lettering see page 282.)

it joins the mandible laterad to the depression (D). The distal margins of the mandibles are armed with stout teeth. The outer margin bears approximately sixteen which are terminally directed and are somewhat larger than those borne on the inner margin. About twenty-seven backward directed teeth are borne on the inner margin. Faint striations are present for a short distance along the blade beginning from points between the marginal teeth.

In the center of each mandible is an oval-shaped area which is a depression in the ventral side of the blade (D., fig. 11) and a projection on the dorsal side (D. P., fig. 15). The projection is better seen from a lateral view (D. P., fig. 12).

Nitzulescu (1926, 1928) was the first to make a careful study of these projections in the Simuliidae. He stated that the projections differ in position from those described by Jobling (1928) on the mandibles of *Culicoides*, being dorsal in the Simuliidae and ventral in *Culicoides*. In *Culicoides*, according to Jobling (1928), the position of the mandibles, one superior to the other, is maintained by the conformation of the tubercle of the superior mandible to the depression of the inferior one. The process on the ventral side of the inferior mandible interlocks with the lumen of the salivary duct of the hypopharynx.

Nitzulescu (1928) stated that the mandibles of the Simuliidae are not exactly superimposed as are those of *Culicoides*, especially in the posterior part of the proboscis. He showed that the dorsal projections fit against the sides of a groove in the ventral side of the labrum-epipharynx with the same results as that produced in *Culicoides*, since they prevent the spreading of the mandibles during feeding and determine, as with *Culicoides*, the constitution of the food channel.

Gibbins (1938) thought the projections to occur on the ventral surfaces of the mandibles. He believed that the mandibles function as a pair of "scissors" to "snip" the skin, with the mandibular projections acting as a fulcrum.

The writer concurs with the opinion of Nitzulescu. The mandibular projections are dorsal and they possibly fit against the sides of the groove in the labrum-epipharynx as a means of anchoring the mandibles in position during feeding. When an attempt is made to fit the projections together in the dissected specimen it is found that the tips of the mandibles overlap to such an extent that they could not possibly function in the manner of a pair of scissors. A study of fig. 15 will suffice to show that this would be the case. Moreover, when the tips are placed one superior to the other, as they would have to be to form the posterior wall of the food channel, the projections are situated well apart.

### THE LABRUM-EPIPHARYNX

The labrum-epipharynx (Lre., figs. 1, 2 and 3) is a compound structure formed of the labrum and the epipharynx. The frame-work of the labrum consists of three heavily sclerotized rod-like processes, two lateral (L. P., figs. 13 and 14) and one median (M. P.) which is dorsad of the other two. The three processes meet at their distal extremity in a triadate manner. The areas between the processes are membranous. The epipharynx (E., figs. 13, 14, 21 and 22) is a lightly

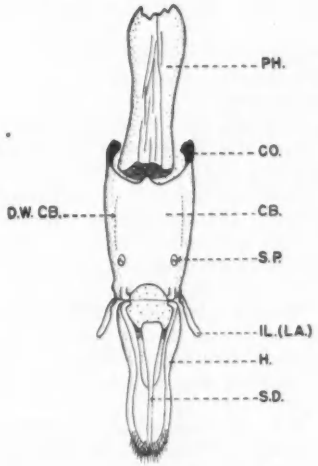


FIG. 17.

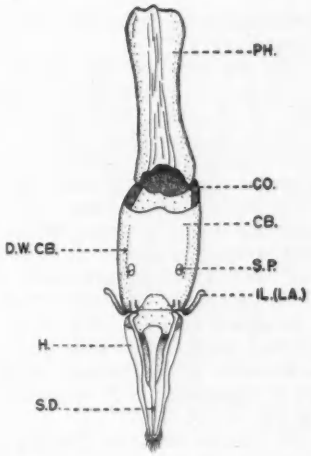


FIG. 18.

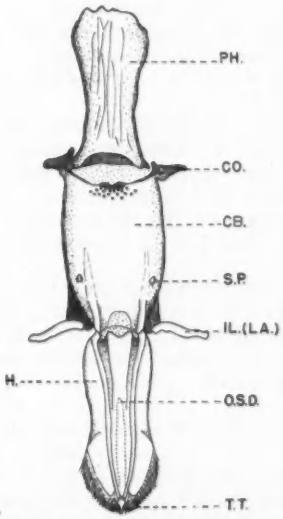


FIG. 19.

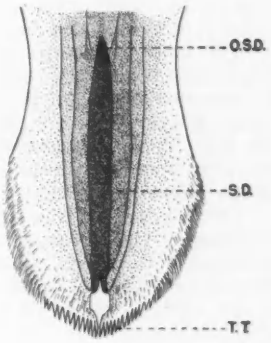


FIG. 20.

FIGURE 17. *Eusimulium dacotense* D. & S., ventral view of hypopharynx, cibarial pump and pharyngeal pump of female. 18. *Eusimulium dacotense* D. & S., ventral view of hypopharynx, cibarial pump and pharyngeal pump of male. 19. *Simulium venustum* Say, ventral view of hypopharynx, cibarial pump and pharyngeal pump of female. 20. *Simulium venustum* Say, dorsal view of tip of hypopharynx of female.

(For Key to Figure Lettering see page 282.)

sclerotized rectangular plate set in the membrane between the lateral processes.

The median process (M. P.) is triangular in cross section. In *S. venustum* it is broadened distally and bears two sets of three large teeth (T. T., figs. 14 and 16) projecting dorsally. These teeth are absent in *E. dacotense*. Cragg (1913) believed that their function is to hold the labrum-epipharynx in position in the wound during feeding. This view is upheld by Baranov (1927) and by Gibbins (1938).

The ridge of the median process in *S. venustum* bears short backward-projecting spines between the terminal teeth and the tormae (fig. 14). These spines are absent in *E. dacotense*, this species bearing only a few setae toward the posterior end of the median process.

The posterior one-third of the median process (P. P., fig. 14) in *S. venustum* extends back under the clypeus. Jobling (1928) states that this posterior process in *Culicoides* serves for the attachment of the elevator and depressor muscles of the labrum-epipharynx. This part is degenerate in *E. dacotense* and is present only as a membranous strip (P. P., fig. 13).

The lateral parts of the labrum (L. P.) are attached proximally to the antero-lateral walls of the cibarial pump. Toward the proximal ends heavily sclerotized arms extend dorsally which meet similar arms extending ventrally from the median process. These are the tormae (T., figs. 13 and 14). A third pair of arms, the antero-lateral processes of the clypeus (A. P., figs. 14 and 15), articulate with the tormae at their points of junction. The labrum-epipharynx is joined to the clypeus by these arms and by membrane which extends from the anterior margin to the clypeus.

The lateral processes gradually converge distally where they are fused (figs. 21 and 22). They are flattened and broadened anteriorly in *S. venustum* while in *E. dacotense* they are narrowed. Distally *S. venustum* bears six to eight lightly sclerotized spines at each side of the tip. In *E. dacotense* a membranous lobe extends anteriorly and laterally from the distal extremity. This lobe is thickly set with lightly sclerotized setae.

The epipharynx is a rectangular sclerite lying between the lateral processes of the labrum. In *S. venustum* it is entirely surrounded by membrane (E., fig. 22), while in *E. dacotense* (E., fig. 21) it is fused distally with the lateral processes. In *S. venustum* the ventral surface of the labrum-epipharynx is broadly grooved. This groove is absent in *E. dacotense*.

The ventral surface of the labrum-epipharynx in both species bears a number of pegs (S. P., figs. 21 and 22) which are presumed to be sensory. These sensillae extend in two irregular rows from the tip of the labrum-epipharynx to the base, and appear as clear rings with a dark spot in each. Careful examination shows that the center of each ring bears a minute spicule. Each row contains fourteen to twenty-one of these sensillae. The positions of the sensillae vary considerably among individual specimens. Those sensillae at the distal extremity of the labrum-epipharynx are larger than the others, as are two situated at or slightly behind the middle of the epipharynx.

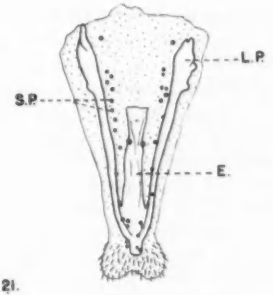


FIG. 21.

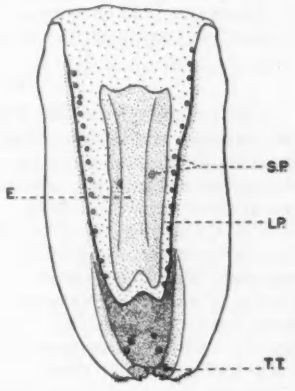


FIG. 22.

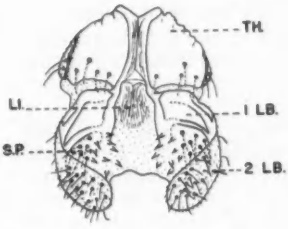


FIG. 23.

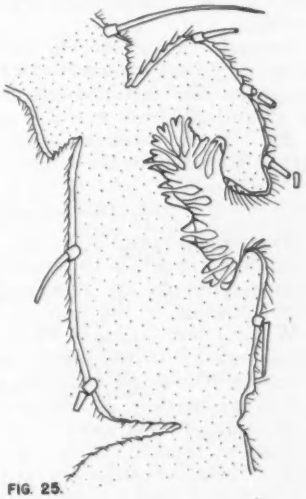

FIG. 25.

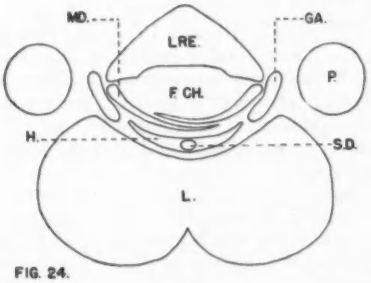


FIG. 24.

FIGURE 21. *Eusimulium dacotense* D. & S., ventral view of labrum-epipharynx of male. 22. *Simulium venustum* Say, ventral view of labrum-epipharynx of female. 23. *Eusimulium dacotense* D. & S., dorsal view of labium of male. 24. *Simulium* sp., diagramatic cross section of the mouthparts through theca. 25. *Eusimulium dacotense* D. & S., longitudinal section of third segment of palp and sense organ of male.

(For Key to Figure Lettering see page 282.)

The labrum-epipharynx is essentially the same in both sexes of *E. dacotense*. When compared with that of *S. venustum* it is seen to be shorter, narrower and in general less heavily constructed.

### THE HYPOPHARYNX

The hypopharynx (H., figs. 13, 14, 17, 18 and 19) articulates with the anterior end of the cibarial pump and lies dorsal to the labium. Its sides are turned up, giving it the shape of a trough. Laterally it is strengthened by heavy sclerotizations which extend from the points of articulation with the cibarial pump to the distal extremity.

The distal portion of the hypopharynx differs considerably between the male and female *E. dacotense* as well as between this species and *S. venustum* (figs. 17, 18 and 19). Considering *E. dacotense* we find that the tip of the hypopharynx is densely clothed with long setae in both sexes, but in the male (fig. 18) the tip is only half as wide as in the female (fig. 17). In *S. venustum* (fig. 19) the tip is somewhat flattened ventrally and is broader than that of the female of *E. dacotense*. Laterally it bears a fringe of long setae which is directed forward (figs. 14, 19 and 20). Distally these setae are replaced by a number of stout teeth. Ventrad of this fringe is another fringe of downwardly directed setae (fig. 14).

Ventrally and proximally the hypopharynx bears a keel-like ridge. The salivary duct extends through this ridge and in *S. venustum* opens dorsally on the posterior two-fifths of the hypopharynx (O. S. D., figs. 19 and 20) from where it extends to the tip as a groove (S. D., fig. 20). In *E. dacotense*, both male and female, the salivary duct exists as a groove for the entire length of the hypopharynx.

### THE CIBARIAL AND PHARYNGEAL PUMPS

The cibarial pump (Cb., figs. 13, 14, 17, 18 and 19) is a trough-shaped organ to which the proximal ends of the hypopharynx and the labrum-epipharynx are attached. It occupies a median and nearly vertical position in the head capsule. The dorsal wall of the organ (D. W. Cb.), the outline of which can be seen in the figures, is thin and is invaginated into the lumen; whereas the lateral and ventral walls are heavily sclerotized and form a gutter.

Situated laterally on the ventro-distal third of the cibarial pump are two circular clear spots (S. P., figs. 17, 18 and 19). Each of these contains two minute, darkly pigmented setae which are presumed to be sensory. These sensillae are on the interior surface so that they come in contact with food passing through the organ. Emery (1913) called these gustatory sensillae.

Articulating disto-laterally with the cibarial pump are found the two bar-like structures (Il. (La.) ) which were described in connection with the maxillae. Posteriorly the dorso-lateral parts of the cibarial pump are produced as heavily sclerotized arms, the cornuae (Co.), which serve as points of muscle attachment. Between the cornuae on the ventral wall in *S. venustum* are a group of heavily sclerotized papillae. These are absent in *E. dacotense*. They do not appear to be sensory in nature.

The pharyngeal pump (Ph., figs. 13, 14, 17, 18 and 19) is located posteriorly to the cibarial pump. The posterior end of this structure extends to the occipital foramen (Ph., fig. 4). In cross section it is a triangular structure composed of three plates which are joined laterally by membrane.

Jobling (1928) stated that the pharyngeal (oesophageal) pump is well developed in all blood-sucking Orthorrhapha. He believed that the pumping action is brought about by the action of the cibarial (pharyngeal) and pharyngeal (oesophageal) pumps together. Concerning the function of these organs he wrote,[4] "The contraction and relaxation of the bands of the dilators of the pharynx (cibarium) do not take place simultaneously. The action of these muscles produces a peristalic movement of the membranous dorsal wall of the pharynx (cibarium). When the bands of the dilator contract, the anterior part of the oesophagus (pharynx) is closed by the contraction of the anterior sphincter of the oesophageal (pharyngeal) pump and the blood fills up the lumen of the pharynx (cibarium). During the relaxation of the bands of the dilator of the pharynx (cibarium) the anterior sphincter is relaxed, whereas the posterior sphincter is contracted and the blood passes into the lumen of the oesophageal (pharyngeal) pump, which is dilated by the contraction of its own muscles. During the relaxation of the muscles of the oesophageal (pharyngeal) pump the posterior sphincter is relaxed, and the blood passes toward the crop, since the passage into the pharynx (cibarium) is closed by the contracted anterior sphincter."

### THE LABIUM

The labium (L., figs. 4 and 23) is composed of the postmentum, theca and the labella. The postmentum (M., figs. 5 and 6) occupies a position on the posterior surface of the head between the stipites. This area is more lightly sclerotized than the stipites and is continuous with them (figs. 5 and 7).

The theca (Th., fig. 23) is thick walled and is attached to the posterior surface of the head by means of a membrane. According to Jobling (1928) it is formed by the fusion of the palpigers. Along the line of fusion the reduced inner walls of the palpigers remain as two invaginations. Laterally the edges of the theca bend dorsally.

The labella represent the modified labial palps according to Jobling (1928). The first and second labella (1 Lb. and 2 Lb., fig. 23) are fused but are clearly indicated by outward sclerotizations. Externally the labella and theca are covered with short spines and bear numerous long setae as well. The inner faces of the second labella each bear ten to fourteen sensory pegs (S. P., fig. 23).

The ligula (Li., fig. 23) occupies a position in the ventral wall of the labium at the base of and between the labella. It is a membranous structure which presents a peculiar branched vein-like appearance. The ligula is attached by a membrane to the ventral side of the hypopharynx at its tip. Snodgrass (1943) states that the ligula represents the glossae and paraglossae.

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[4]Jobling, 1928; p. 230.

The labium functions as a sheath for the other mouthparts. Smart[5] (1935) states that when a blackfly is biting the distal extremities of the labella surround the labrum and other mouthparts which are slowly inserted into the skin of the host, embraced and guided by the lebella.

### BIOLOGY OF EUSIMULIUM DACOTENSE D. & S.

This species is widely distributed throughout Minnesota yet it cannot be considered a common one. It has been found breeding in both permanent and temporary streams. It appears to have but one generation a year, the adults emerging early in May. The writer was unable to locate the larval stage during the summer.

At the time of emergence the adults collect in great numbers on protruding rocks in the stream and on the banks near the place of emergence, and mating occurs on the ground soon afterwards. Specimens reared from pupae which were kept on moist cotton in tubes were observed to mate and deposit eggs in the rearing tubes within twenty-four hours after emergence, but attempts to hatch these eggs were unsuccessful.

Although the emergence of this species was observed at various streams over a period of three seasons and the adults were extremely abundant at these places, none of them ever attempted to bite the writer. Neither were they ever observed feeding from the blossoms of the numerous species of wild flowers which grew nearby. Adults kept in captivity lived only two days.

### SUMMARY

The writer has described in detail and figured the mouthparts of both sexes of *Eusimulium dacotense* D. & S., a species whose mouthparts are so weakly developed that they cannot be used to pierce the skin in order to feed on blood. A comparison is made with the mouthparts of the biting blackfly, *Simulium venustum* Say. Notes on the biology of *E. dacotense* are included.

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[5]Smart, 1935; p. 164.

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**Patton, W. S.** and **Cragg, F. W.** 1913. A text-book of medical entomology. London, Madras & Calcutta, p. 23.
**Smart, J.** 1935. The internal anatomy of the black-fly *Simulium ornatum* Mg. Ann. Trop. Med. & Parasit. 29: 161–170.
**Snodgrass, R. E.** 1935. Principles of insect morphology. New York and London.
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INSECTS OF KANSAS, by ROGER C. SMITH, E. G. KELLY, GEO. A. DEAN, H. R. BRYSON and R. L. PARKER. 1943. Report of the Kansas State Board of Agriculture, June, 1943, pp. 1–440, 464 figs., 6 col. plates.

The cover title is Insects in Kansas, the inner title is Common Insects of Kansas, the banner head is Insects in Kansas. Perhaps the College Editor is in a political party other than that of the State Printer at Topeka. Also there is the Secretary of the State Board of Agriculture, who contributes the preface. Three pages of subdued political advertising infringe on space for entomology. The paper of the first 208 pages is gray white, the remainder pink white. The six once lovely plates have been reproduced in three colors without black, which gives them a washed-out appearance.

It is unfortunate when a volume of such excellent entomological work gets state publication of such questionable quality. All entomologists are hoping that the remarkable work entomologists are doing in the present war will give common man, including all politicians, more respect for our science. Perhaps World War II will do even more in the rehabilitation of the U. S. A. than it can hope to do for European countries. We need some of it ourselves. Modern entomology is eminently worthy of respect.

The first 116 pages gives a good discussion of the features and problems of Kansas Entomology from "What an Insect Is" to the marvelous fossil beds. The remainder is taxonomic and covers common and conspicuous insects. As an example, about 70 species of Odonata are known from the state. The text keys out and describes ten species which are fairly well selected from the whole series. Four are illustrated. It is the best volume, probably free to all citizens of Kansas, that we know of for the farmer and particularly any farmer's son or school child who might have an interest in insects. The many illustrations make it very usable in the hands of a non-technically trained student. The present writer feels that common names where available should have been displayed more adequately as encouragers to the non-scientifically trained. The average scientist forgets how baffling scientific terminology is to the usually well informed reader. The common names are buried in the text.

We doubt if the volume will help up-to-the-minute entomology much, as it does not deal with specific economic problems, but it will probably do even better in starting a crop of young entomologists some of whom may persist to make entomology a life work. We need them. It is the type of publication the average entomologist does not like to take time out to write, but more of which should be done for local faunas and local problems. We feel that the authors have done a praiseworthy thing which will get results in Kansas and central plains states.

—C. H. K.

# PUBLICATIONS OF THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

The following information has been received concerning publications of the Commission to December 31, 1944.

Opinions and declarations rendered by the Commission are being published in three volumes concurrently as follows: VOLUME 1, containing nine declarations never previously published and a reissue of Opinions 1–133, the original issue of which is not exhausted; VOLUME 2, containing Declarations 10–12 and Opinions 134–181, all of which were adopted by the International Commission at their meeting held at Lisbon in 1935; VOLUME 3, containing Opinions adopted by the Commission since their Lisbon meeting. The titles of the parts so far issued are:

VOLUME 1 (1943– )

PART 1.—Declaration 1. Code of ethics to be observed in the renaming of homonyms. Price, one shilling and sixpence.

PART 2.—Declaration 2. On the importance of avoiding the issue of authors' reprints or separates in advance of the publication of the work or journal in which the paper in question is to be published. Price, one shilling and sixpence.

PART 3.—Declaration 3. On the importance of giving a clear indication of the date of issue of every zoological publication. Price, one shilling and sixpence.

PART 4.—Declaration 4. On the need for avoiding intemperate language in discussion on zoological nomenclature. Price, one shilling and sixpence.

PART 5.—Declaration 5. On the grant to the International Commission on Zoological Nomenclature of plenary powers to suspend the rules in certain cases. Price, two shillings and sixpence.

PART 6.—Declaration 6. On the need for new names to be clearly indicated as such on their first publication and on the need for avoiding the publication of names as new on more than one occasion. Price, one shilling and sixpence.

PART 7.—Declaration 7. On the need for quoting bibliographical or other references for all names cited in zoological works. Price, one shilling and sixpence.

PART 8.—Declaration 8. On the need for giving in the case of zoological journals a clear indication of the date of publication. Price, one shilling and sixpence.

PART 9.—Declaration 9. On the desirability of Universities including zoological nomenclature in their courses of general and systematic zoology. Price, one shilling and sixpence.

PART 10.—Opinion 1. The meaning of the word "indication" in proviso (a) to Article 25 of the International Code, as respects names published on or before Dec. 31, 1930. Price, four shillings.

PART 11.—Opinion 2. The nature of a systematic name. Price, one shilling and sixpence.

PART 12.—Opinion 3. The status of publications dated 1758. Price, one shilling and sixpence.

PART 13.—Opinion 4. The status of names published as manuscript names. Price, three shillings.

PART 14.—Opinion 5. The status of certain pre-Linnean names reprinted subsequent to 1757. Price, three shillings.

PART 15.—Opinion 6. On the type of a genus "A——," containing two species, "A—— b——" and "A—— c——," where the generic name in question was published on or before Dec. 31, 1930. Price, three shillings.

VOLUME 2 (1939– )

PART 1.—Opinion 134. On the method to be adopted in interpreting the generic names assigned by Freyer to species described in his *Neure Beiträge zur Schmetterlingskunde*, 1833–1858. Price, eight pence.

PART 2.—Opinion 135. The suppression of the so-called "Erlangen List" of 1801. Price, eight pence.

PART 3.—Opinion 136. Opinion supplementary to Opinion 11 on the interpretation of Latreille's *Considerations generales sur l'ordre naturel des animaux composant les classes des Crustaces, des Arachindes et des Insectes avec un tableau melhodique de leurs genres disposes en familles*, Paris, 1810. Price, one shilling.

PART 4.—Opinion 137. On the relative precedence to be accorded to certain generic names published in 1807 by Fabricius and Hübner respectively for identical genera in the Lepidoptera Rhopalocera. Price, one shilling and sixpence.

PART 5.—Opinion 138. On the method by which the Amendment to Article 25 of the International Code adopted at the Budapest Meeting of the International Zoological Congress, relating to the replacement of invalid names, should be interpreted. Price, one shilling and sixpence.

PART 6.—Opinion 139. The name *Cephus* Latreille (1802–1803) and *Astata* Latreille (1796) in the Hymenoptera added to the Official List of Generic Names. Price, two shillings and sixpence.

PART 7.—Opinion 140. On the method of forming the family names for *Merops* Linnaeus (1758, Aves) and for *Merops* Newman (1838, Insecta). Price, two shillings.

PART 8.—Opinion 141. On the principles to be observed in interpreting Article 4 of the International Code relating to the naming of families and subfamilies. Price, two shillings and sixpence.

PART 9.—Opinion 142. Suspension of the Rules for *Satyrus* Latreille (1810, Insecta: Lepidoptera). Price, two shillings and sixpence.

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PART 11.—Opinion 144. On the status of the names *Crabro* Geoffroy (1762), *Crabro* Fabricius (1775) and *Cimbex* Olivier (1790) (Insecta: Hymenoptera). Price, two shillings and sixpence.

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PART 13.—Opinion 146. Suspension of the rules for *Colias* Fabricius (1807, Insecta: Lepidoptera). Price, two shillings and sixpence.

PART 14.—Opinion 147. On the principles to be observed in interpreting Article 34 of the International Code in relation to the rejection, as homonyms, of generic and subgeneric names of the same origin and meaning as names previously published. Price, two shillings and sixpence.

PART 15.—Opinion 148. On the principles to be observed in interpreting Articles 25 and 34 of the International Code in relation to the availability of generic names proposed as emendations of, or as substitutes for, earlier generic names of the same origin and meaning. Price, two shillings and sixpence.

PART 16.—Opinion 149. Twenty-one names in the Orthoptera (Insecta) added to the Official List of Generic Names in Zoology. Price, four shillings.

PART 17.—Opinion 150. On the dates of publication of the several portions of Hübner, J., *Verzeichniss bekannter Schmetterlinge*, 1816–1826. Price two shillings and sixpence.

PART 18.—Declaration 10. On the importance of forming specialist groups for the study of nomenclature of particular divisions of the Animal Kingdom. Price, one shilling and sixpence.

PART 19.—Declaration 11. On the need for a clear indication in the description of new genera and species of the Order and Family involved. Price, one shilling and sixpence.

PART 20.—Opinion 151. On the status of the names *Lasius* Panzer (1801–1802), *Podalirius* Latreille (1802), *Lasius* Fabricius (1804–1805), and *Anthophora* Latreille (1803) (Insecta: Hymenoptera). Price, three shillings.

PART 21.—Opinion 152. On the status of the generic names in the Order Diptera (Insecta) first published in 1800 by J. W. Meigen in his *Nouvelle Classification des Mouches a deux ailes*. Price, four shillings.

PART 22.—Declaration 12. On the question of breaches of the Code of Ethics (Declaration supplementary to Declaration 1). Price, one shilling and sixpence.

PART 23.—Opinion 153. On the status of the names *Bethylus* Latreille (1802–1803) and *Dryinus* Latreille (1804) (Insecta: Hymenoptera). Price, three shillings.

PART 24.—Opinion 154. On the status of the names *Phaneroptera* Serville (1831) and *Tylopsis* Fieber (1853) (Insecta: Orthoptera). Price five shillings.

PART 25.—Opinion 155. On the status of the names *Callimome* Spinola (1811), *Misocampe* Latreille (1818) and *Torymus* Dalman (1820) (Insecta: Hymenoptera). Price, three shillings.

PART 26.—Opinion 156. Suspension of the rules for *Vanessa* Fabricius (1807) (Insecta: Lepidoptera). Price, three shillings.

VOLUME 3 (1944– )

PART 1.—Opinion 182. On the status of the names published by Gümbel, C. W., in 1863 for subdivision of the genus *Clymenia* Münster (1832, Cephalopoda: Ammonidea). Price, three shillings.

PART 2.—Opinion 183. On the principles to be observed in interpreting Article 8 of the International Code in relation to the form in which generic and subgeneric names are to be published. Price, three shillings.

PART 3.—Opinion 184. On the status of names first published in volumes 1 to 11 of Martini, F. H. W., and Chemnitz, J. H., *Neues systematisches Conchylien-Cabinet*, Nürnberg, 1769–1795. Price, three shillings.

PART 4.—Opinion 185. Suppression of Bodadsch, J. B., *De quibusdam Animalibus marinis*, 1761, and of the German translation thereof published by Leske, N. G., in 1776. Price, four shillings.

BULLETIN OF ZOOLOGICAL NOMENCLATURE

This journal was established by the International Commission in 1943 to be their Official Organ, in order to provide a medium for the publication of:

(a) Proposals on zoological nomenclature submitted to the International Commission for deliberation and decision;
(b) Comments received from, and correspondence by the Secretary with zoologists on proposals published in the Bulletin under (a) above; and
(c) Papers on nomenclatorial implications of developments in taxonomic theory and practice.

Four parts of Volume 1 have so far been published. The prices of these parts are: 9/–, 5/–, 30/– and 6/– respectively.

ORDERS FOR THE COMMISSION'S PUBLICATIONS

All orders for the publications of the Commission should be addressed to the International Commission on Zoological Nomenclature at its Publications Office, 41 Queen's Gate, London, S. W. 7.

REMITTANCES FROM OVERSEAS

It is requested that all remittances be made in pounds sterling to avoid errors due to loss from bank charges and fluctuations in foreign exchange.

The above information has been circulated by MR. FRANCIS HEMMING, Secretary to the International Commission on Zoological Nomenclature.—A. W. L.

# BOOK NOTICES

ACTA ZOOLOGICA LILLOANA. Published by the Instituto Miguel Lillo, Universidad Nacional de Tucuman, Calle Miguel Lillo 205, Tucuman, Republica Argentina, under the direction of HORACIO R. DESCOLE.

Volume II, No. 1 of the Acta Zoologica Lilloana exemplifies a scientific journal of high quality. The paper and format of well spaced and easily read type leads one to wish that our own publications were not faced with serious need for economy in such details.

With the exception of a brief article on the embryology of a fish, supplemented with five interesting half-tone plates with interpretive line-cut inserts, this number is given over wholly to articles on insects, hence the publication is likely to be of great interest to entomologists.—A. W. L.

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THE IMPORTED LONG-HORNED WEEVIL, *CALOMYCTERUS SETARIUS* ROELOFS, by J. PETER JOHNSON. Connecticut Agricultural Experiment Station, New Haven, Bulletin 479, 22 pages, 16 figures, 1944.

Since the reviewer spent part of the summer of 1917 on his belly in a hot alfalfa field trying unsuccessfully to solve the mysteries of the life history of a weevil, the account given in this bulletin seems a fine tribute to its writer. Like so many other nuisances, the beetle came from Japan. It was discovered in the United States in 1929. The bulletin includes data on its distribution in this country, the life cycle, morphology and habits. A long list of food plants is included. A brief discussion of control measures indicates that treatment with cryolite dust gave the best results.—A. W. L.

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DYNASTINAE OF NORTH AMERICA, WITH DESCRIPTIONS OF THE LARVAE AND KEYS TO GENERA AND SPECIES (COLEOPTERA: SCARABAEIDAE), by P. O. RITCHER. Kentucky Agricultural Experiment Station, Lexington, Bulletin 467, 56 pages, 90 figures of anatomical details in 5 plates and 12 text figures of adults. 1944.

The preliminary section includes a clear discussion of the material and procedure of the revision and a detailed description of the third stage larva of *Cyclocephala immaculata* Oliv., the stage on which the key to larvae is based. The title seems slightly misleading. It should be noted that the keys deal only with larvae. The paper, typography and illustrations are excellent.—A. W. L.

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TREATMENT OF EXPERIMENTAL DATA, by ARCHIE G. WORTHING and JOSEPH GEFFNER. Pages ix and 342, 95 figures. Published by John Wiley & Sons, Inc., New York. 1943. Price, $4.50.

This book contains a wealth of material that is well organized and illustrated, and is written in a clear concise style. The general subject matter covered in the text is indicated by the chapter headings as follows: Chapter I, Representation of Data by Tables; Chapter II, Representation of Data by Graphs; Chapter III, Representation of Data by Equations; Chapter IV, Tabular and Graphical Differentiation and Integration; Chapter V, Fourier Series; Chapter VI, The Normal Frequency Distribution; Chapter VII, The Normal Frequency Distribution (continued); Chapter VIII, Means and Precision Indexes of Unequally Weighted Measurements; Chapter IX, The Propagation of Precision Indexes; Chapter X, The Adjustment of Conditional Measurements; Chapter XI, Least-Squares Equations Representing Observed Data; Chapter XII, Correlation; Chapter XIII, The Analysis of Non-Harmonic Periodic Functions. A summary of the discussions and a list of problems are included at the end of each chapter. Appendix 1 is a review of determinant methods which simplify and shorten many treatments and have been used wherever convenient in the discussions. Appendix 2 includes tables of probability functions, chi-square, constants for least square solutions, both common and natural logarithms, square roots, and trigonometric functions.

The bibliography consists of a short list of books and articles that are classified according to different fields of interest and there is a complete index.

The preface states that the present textbook is an outgrowth of a course for graduate students at the University of Pittsburgh and that it was written especially for the physicist, the chemist, and the engineer. Many of the discussions are, therefore, rather mathematically advanced, but much of the work, such as that on methods of smoothing, tabulating, graphing, and representation by equations to bring out the worth of the data to the greatest extent, seems invaluable to the experimental biologists and research workers in most other fields as well.

Some topics of special interest to workers in the agricultural sciences, such as the analysis of variance and design of field plot experiments, have not been treated here, but discussions of these subjects are available from numerous sources that do not contain other important discussions found in the present text.

—F. H. HARRIES.

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MICROENTOMOLOGY, Vol. 9, Part 2, 1944. Contents:

No. 44, Cook, E. F. Morphology of the larval heads of certain Culicidae (Diptera). Pages 38–68, figures 19–35.

No. 45. Cook, E. F. Morphology of the larval head of Eheronomus (Diptera: Chironomidae). Pages 69–77, figures 36–39.

No. 46. Ferris, G. F. Certain evolutionary tendencies in the heads of insects. Pages 78–84, figures 4.

We are again calling attention to microentomology because editorial problems have always interested us. Ferris gets this journal published at a surprisingly low cost. It is lithoprint; it is folded but once, has no cover; is on excellent paper and has a clear, clean type face. The illustrations are cleaner and better than the zinc etchings in these Annals. It still has the faulty irregular right edge to the text. But shortly compensating machines will be used to correct this fault. It has the other fault that the print is slightly gray and not the intense black of good print.

It has a fault that is editorial and which the compositor on these Annals would not tolerate, if he lost the Annals' patronage. Some of the plates are turned so that the plate legend runs across the plate while the explanations of the figures run up and down, necessitating turning the plate to read them. Editorially such a trick to save space is wild stuff; but all innovations are at first wild, and later generations of editors may glow over them as good format. In good format title pages, introduction, table of contents, text, illustrations, and index flow evenly from left to right from page 1 to the end. In the March issue the Annals has introduced several plates designed on the Coast which show this Ferrisian twist. With printing costs jumping as at present the smaller journals should look into lithoprinting to see if it is at all feasible. As compared with the Annals costs Ferris' costs are incredibly low. Ferris has opened the way at a University Press of high repute. It is a clever move.—C. H. K.

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THE FOUNDATIONS OF PLANT GEOGRAPHY, by STANLEY CAIN, Professor of Botany, University of Tennessee. Pages xiii and 556, 32 tables, 63 figures. Published by HARPER AND BROS. Price $5.00.

This very interesting volume is one of those treatments of speciation and distribution which we have wished for over a period of at least twenty years. However, it could not have appeared much earlier as some phases of our present knowledge of speciation and of the composition of populations have been developed only recently. Further the youthful science of ecology had to learn that it could not supply all the answers. Some of the disciples of ecology properly indoctrinated into that science appeared to feel towards plant geography much as a graduate of a First Class College of Medicine feels toward osteopathy or chiropractic. The attitude had to mellow before various problems could be solved. At present the best work in geographic distribution in ecology and in the genetics of populations is fusing a science that at least is becoming very interesting and which appears to give more pleasing answers to problems of the flux of distribution.

The following list of subjects should intrigue any student of speciation and perhaps even the addicts of identification, labeling and cataloguing. They run:

PART I. Introduction: 1. Plant Geography as a Borderline Science. 2. Certain Previously Proposed Principles.

PART II. Paleoecology. 3. Paleoecology and Limitations of Method; 4. Identifications of Fossils; 5. Determinations of Dominance in a Fossil Flora; 6. Determinations of Living Conditions of a Fossil Flora; 7. Determination of the Structure of the Vegetation of a Fossil Flora; 8. Migration and Evolution; 9. Certain Aspects of the History of Cenozoic Vegetation of Western America; 10. Pollen Analysis as a Paleoecological Research Method.

PART III. Areography. 11. Some Terms and Concepts of Area; 12. Dispersal and Migration; 13. Center of Area; 14. Criteria for the Indication of Center of Origin; 15. Endemics and Endemism; 16. Species Senescence; 17. Discontinuous Distribution; 18. Vicarious Forms and Areas; 19. Polytopy and Polyphylesis; 20. Theory of Differentiation in Relation to the Science of Area.

PART IV. Evolution and Plant Geography. 21. Some Principles Concerning Evolution, Speciation and Plant Geography; 22. Nature of Species; 23. Isolation; 24. Causes of Species Stability; 25. Rate of Evolution and Speciation.

PART V. Significance of Polyploidy in Plant Geography. 26. Preliminary Consideration of Polyploidy; 27. Origin and Characteristics of Polyploidy; 28. Principles Concerning Polyploidy and Related Topics; 29. Geographic Aspects of Polyploidy; 30. Polyploidy and Phylogenetic Relationships.

Glossary, 16 pages: Literature Cited, 720 titles; Index, 28 pages.

As the Literature Cited indicates, the volume is a clear and precise digest of a great number of very carefully selected publications. Apparently it is closely limited to papers on plants. Kinsey is cited but not Ernst Mayr. Carl L. Hubbs is omitted. Dobzhansky is included. In speciation and distribution the zoologists have contributed about as much as have the botanists. The author has excluded much critical work by limiting the work to Plant Geography.

As the sixteen pages of Glossary show, Cain is a natural linguist. He loves words, a Greek or Latin term for every process or result. We shudder at dictionaries but any reader will surely have to use the glossary. Some of the terms are lovely polysyllabic Greek words but too often the next term, perhaps in the same sentence, is equally strange but bobtailed. One of our great disappointments in life is that Anglo-Saxon, a servants' language used in the kitchen and stable, is not rich enough to furnish us our scientific terminology. It is simple, direct and to the point. It furnishes the strongest words in our language, the terms of endearment that help hold the family together, also our profanity and obscenity. Our own experience with biological terminology is that too often terms are constants when nearly everything in biology is a variable. Too many are thus deceptive.

Foundations of Plant Geography should be studied by every taxonomist in entomology. The basic problems are similar but those of the distribution of animals are more confused because of locomotion which permits animals to redistribute themselves oftener. It is a must for any student of species and distribution.—C. H. K.

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A CATALOGUE OF THE PARASITES AND PREDATORS OF INSECT PESTS, prepared under the direction of W. R. Thompson, F.R.S., by The Staff of The Imperial Parasite Service. Published by The Imperial Parasite Service, 228 Dundas St., Belleville, Ontario, Canada.

We have before us the first three parts of this ambitious undertaking. Each part is a planitype volume 8½ x 12½ inches, bound in a very heavy, solid cloth cover. Each part is about 150 pages in length. The U. S. Customs declaration put a value of $6.00 on the package containing Parts I and II, duty $0.45.

The work is to be issued in four sections.

SECTION I. Parasite Host Catalogue:

Part 1. Arachnida and Coleoptera; 2. Dermaptera; 3. Hemiptera; 4. Hymenoptera, Isopoda and Isoptera; 5. Lepidoptera, A-C; 6. Lepidoptera, D-G; 7. Lepidoptera, H-M; 8. Lepidoptera, N-P; 9. Lepidoptera, Q-Z; 10. Orthoptera, Psocoptera and Thysanoptera. Ten volumes at $3.00 each?

SECTION II. Parasite Catalogue: "To be issued in parts of convenient size."

SECTION III. Predator Host Catalogue:

Part I. Arachnida, Coleoptera, Collembola and Diptera; 2. Hemiptera; 3. Hymenoptera, Isoptera, Lepidoptera, Mollusca, Myriopoda, Neuroptera, Orthoptera and Thysanoptera.

SECTION IV. Predator Catalogue: "To be issued in parts of convenient size."

The planned size of this work can be better grasped perhaps by the introductory statement: "At the Laboratory (Farnham House) it was realized that, although approximately 100,000 records were held, chiefly taken from the Review of Applied Entomology, there were still a far greater number to be recorded from the literature. It was, therefore, decided that the records held at the Laboratory on December 31, 1937, should be taken as completing the first series of records of the Parasite Catalogue, and that further records appearing in future numbers of the Review of Applied Entomology, and other publications, should be issued in supplements."

Thus to actually get into the literature the student must have access to a set of the several series of volumes of the Review of Applied Entomology which is the main bibliography for this great key to the literature. However, when a reference occurs which is not listed in the Review of Applied Entomology a reference out with author, journal, volume and page is given. We had to hunt to find such references.

Much collaborative help by the U. S. D. A. Division of Insect Identification is acknowledged.

We hope His Majesty and His Majesty's Premier through whatever humble servants are used will give abundant support to this undertaking. British scientists appear to be the only group who can hang on and support such a project as evidenced by such publications as the International Catalogue, The Review of Applied Entomology, etc. Englishmen appear to think ahead, several war periods before they start. Then they have back of them a government with a point of view quite unamerican, but irritating to all world politicians, a view that the Imperial Budget should be kept well balanced. It thrills us. It is one of the projects which will put backbone into world entomology. In fact when we received the volumes and read the dream framed in the Introduction in cold black type we felt faint. The books lay on the editorial desk a year, until we found the right vitamin pills to carry us through the writing of a notice. We have done a modicum of library work in our own time.

What really makes this great undertaking possible is that it has back of it W. R. Thompson, F.R.S. One of our pleasant dreams is that in the next era of gas we can meet Thompson personally for perhaps the length of a few cigarettes and a Scotch and soda or two or three. We have crossed his trail several times. At Cornell we arrived as a graduate student three years after he had left. No student of the brilliant group we found there could crack the aura or remarkable ability as a student that hung over the tales of Thompson. Again when he shifted from the Yéres, France, Parasite Laboratory of the U. S. Bureau of Entomology to Farnham House, Bucks, England, we were impressed with his work in Europe; again when at the beginning of World War II he was one of the distinguished British scientists shifted out of England to the Canadian Belleville Insect Parasite Laboratory to escape possible harm from Nazi bombs we were more than pleased.

Thompson is International. He was born at London, Ontario, in 1887. He took a B.S.A. at the Ontario Agricultural College in 1909; an M.S. at Cornell in 1912; a D.Sc. at Paris, 1921; Ph.D. at St. Maximin, France, in 1924. He was a Demonstrator at the University of Cambridge, England, 1914–15; in the British Navy, 1915–19. He was with the U. S. D. A., 1909–10, 1912–13, 1919–1928, stationed much of the time at the Yéres, France, Laboratory. In 1928 he was made Assistant Director of the Imperial Institute of Entomology, London, England, and at the beginning of World War II was transferred to Belleville, Ontario. No better backing of ability, experience and drive could any similar entomological project have.—C. H. K.

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This deserved word of praise for our Canadian friend is our last official Book Notice, the 435th. Our resignation is in the hands of the Editorial Board. The editorial eye should be relieved of reams of ten-point galley. We have enjoyed our work on the Annals, ten years of pleasurable association with Professor Osborn and fifteen years of wonderful cooperation of Editorial Boards and Officers.

All Hail and Farewell, our Love, the Annals!—C. H. K.

## NOTICE TO MEMBERS AND CONTRIBUTORS

The Annals of the Entomological Society of America, published by the Society quarterly, includes the Proceedings of the Annual Meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, typewritten, and illustrations finished complete ready for reproduction. Plates must not exceed 4¼x6¾ inches unless intended to fold. Cuts for illustrations are charged at cost to the author. In general, papers to be accepted must be original, complete and previously unpublished. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

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During reorganization incidental to the change in editorship all back numbers have been placed in storage, hence it will be impossible to fill orders for an indefinite period. An announcement will be published as soon as arrangements have been completed. Inquiries meanwhile may be addressed to A. W. LINDSEY, Denison University, Granville, Ohio.

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PRINTED IN THE UNITED STATES OF AMERICA
THE SPAHR & GLENN COMPANY, COLUMBUS, OHIO